City University London

Model-Driven Requirements Engineering with *i*:* Synchronising Models in an Air Traffic Management Case Study

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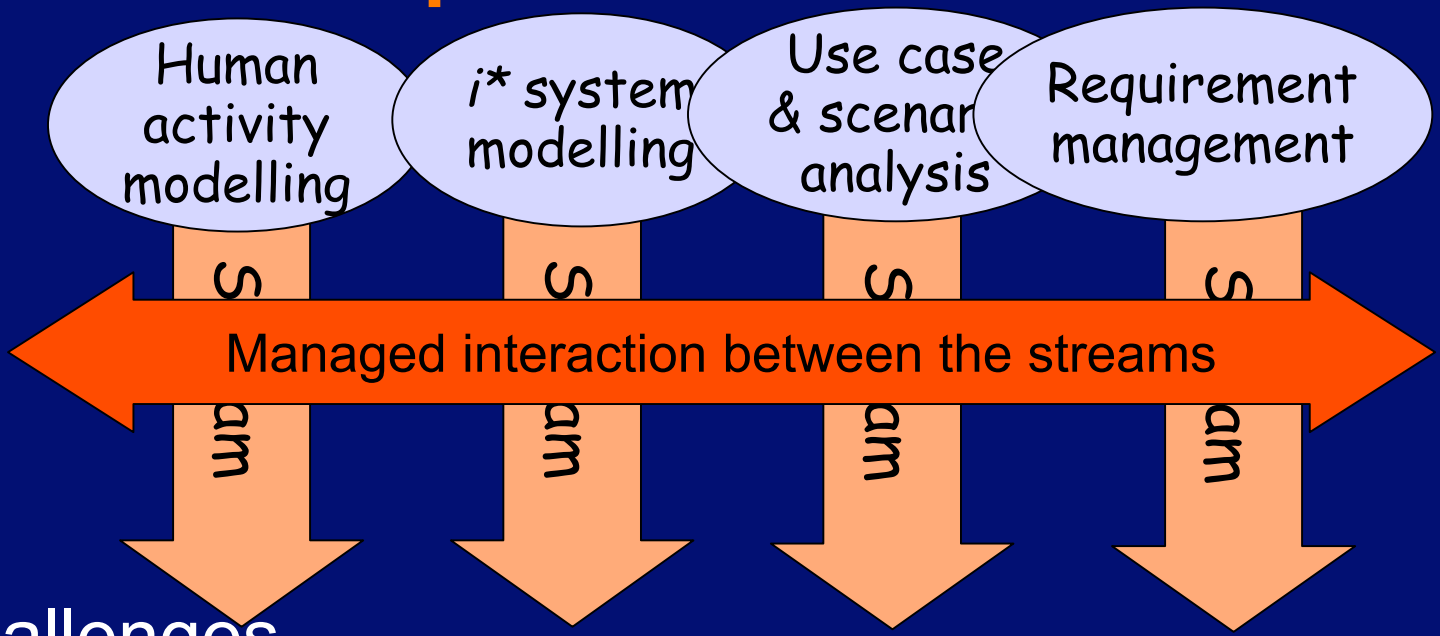
Two-Part Presentation

Process and its application
- RESCUE process
- DMAN project and its *i** models

Case study findings
- Synchronisation checks applied
- Results from synchronisation checks

Discussion and future work

RESCUE Requirements Process



Challenges

- How to scale established research-based techniques such as *i** to large socio-technical systems?
- How to synchronise the use of these techniques - towards new integration theories?

Explored through case study research

The Departure Manager (DMAN) System

Departure manager for major European airports

- Sponsored by Eurocontrol
- Applied RESCUE over 12-month period
- Joint project involving UK and French national bodies
- Applications including Heathrow and Charles de Gaulle

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RESCUE: Human Activity Modeling

HAD5	Pilot calls GMC to request clearance to push back
Author	~~~~~~~~
Date	~~~~~~~~
Source	Observations and interviews 6/3/03 and 2/4/03
Actors	Pilot, GMC
Precis	~~~~~~~~
Goals	Pilot given push back clearance Timely push back clearance given .....
Semantic knowledge	Knowledge of different factors regarding aircraft types; Knowledge of different factors and issues regarding airfield.
Triggering event	Pilot requests push back clearance
Preconditions	Pilot is ready to push back
Assumptions	~~~~~~~~
Normal course	1. Pilot calls for push back *Resources - radio, headset* *Physical actions - flick radio transmission switch, move to look out of window, look at airfield and aircraft, hear pilot call* *Cognitive actions - recognise aircraft, match aircraft with strip*
	2. GMC locates strip in bay ~~~~~~~~
	3. If appropriate, GMC gives push back clearance ~~~~~~~~
	4. GMC puts strip in push back position in bay ~~~~~~~~
	5. Pilot starts engine and does manual checks ~~~~~~~~
	6. Pilot pushes back aircraft ~~~~~~~~
Differences due to variations	4. For some controllers, push back clearance is given to different aircraft in accordance with the order in which pilots have called; others perform more optimisation. ~~~~~~~~~~
Contextual features	1. If night time 1.1 Location is validated via pilot confirmation of position and SMR system ~~~~~~~~
Constraints	Bay size - limited space for strips Noise levels - printer, system alarms, people talking Staff shortage ~~~~~~~~

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	4. The strip has information printed on it: 4.1. SID – 3 letter code not designator 4.2. The number of times the SID has been modified since inception 4.3. Slot time 4.4. Squawk *Cognitive actions - read strip information, recognise information missing / incorrect / unusual*
	5. ATSA checks for slot time against the DSM *Resources - strip, DSM system* *Physical actions - enter information into system* *Communication - interact with system, read information* *Cognitive actions - search / find / read system information, compare printed strip information with system information, recognise information different*
	6. ATSA passes strip to GMP *Resources - strip* *Physical actions - move strip to another desk / controller* *Cognitive actions - recognise when to pass strip to next controller*
	7. GMP puts the strip in the relevant bay *Resources - strip, strip bay* *Physical actions - move strip to required position in bay* *Cognitive actions - acknowledge new strip, read strip information, decide on which bay position to place strip* *Resource Mgmt strategies - strip bays organised into areas, strips ordered in bays: alphabetically by company name, then numerically by call sign, with BA flights separate*
; due to	3. At Gatwick, strips are not printed for arrivals

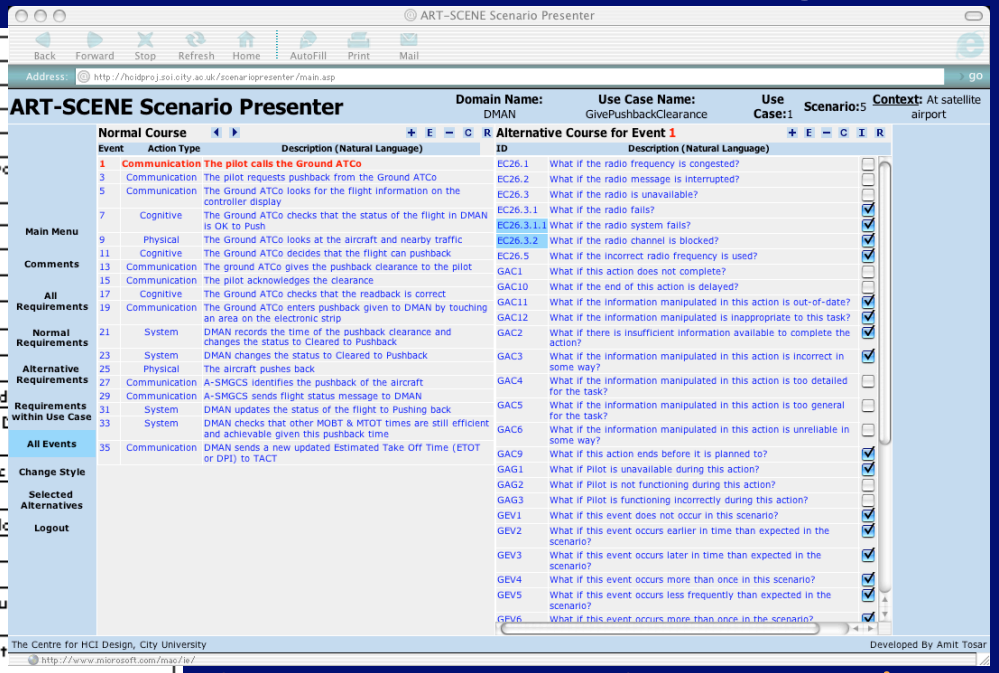
55-page document,
15 AS-IS scenarios

RESCUE: Use Cases and Scenarios

Use case specification of system behaviour

- Supported with ART-SCENE scenario walkthroughs

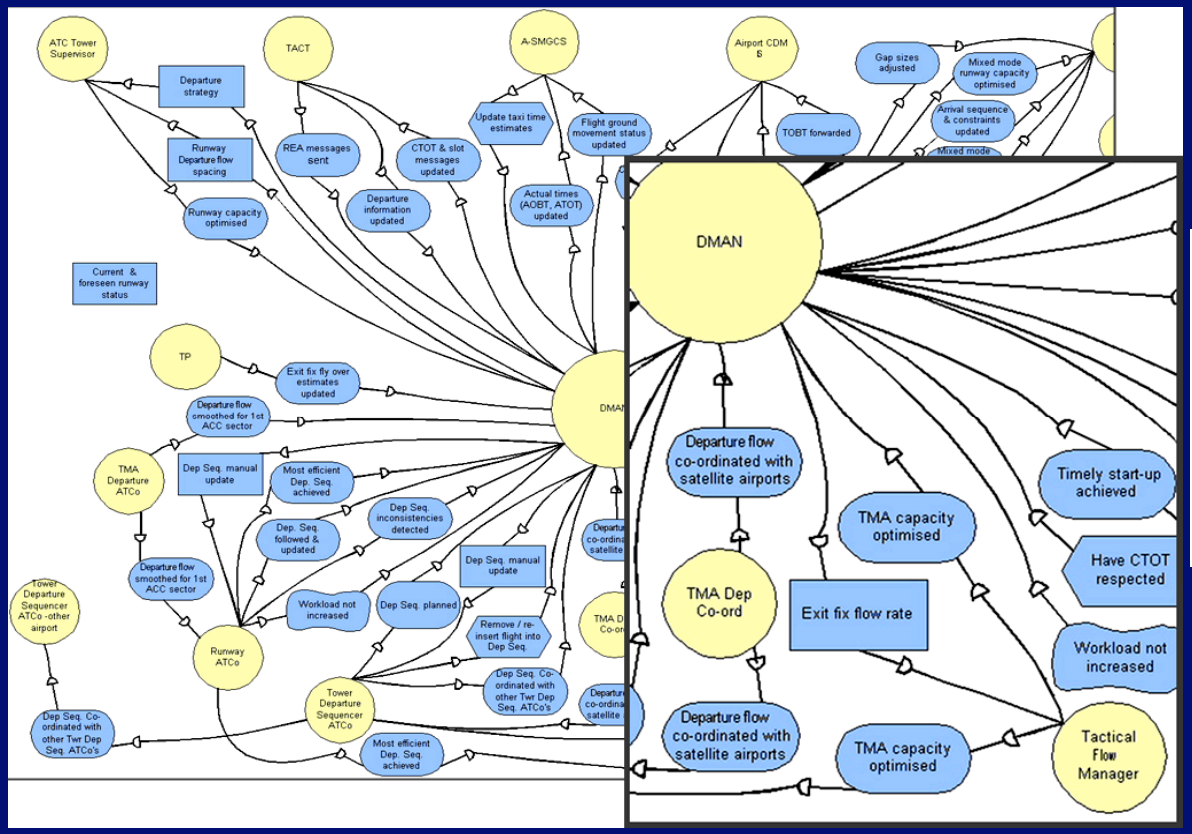
UC03	Give push back clearance
Author	
Date	
Source	RESCUE stage 1
Actors	Pilot, Ground ATCO
Problem statement	Need to improve the way in which clearances to push back fro given to assist runway sequencing ...
Precis	
Triggering event	Pilot requests push back clearance
Preconditions	
Assumptions	
Normal course	1. The Pilot calls the Ground ATCO and requests push back
	2. The Ground ATCO looks for the flight info on the DMAN d
	3. The Ground ATCO checks that the status of the flight in D push'
	4. The Ground ATCO looks at the aircraft and near by traffic
	5. The Ground ATCO decides that the flight can push back
	6. The Ground ATCO gives the push back clearance to the pilo
	7. The pilot acknowledge the clearance
	8. The Ground ATCO checks that the read back is correct
	9. The Ground ATCO enters 'push back given' to DMAN by tou electronic strip
	10. DMAN records the time of push back clearance and updat the flight to 'Cleared to Push back'
	11. The Pilot initiates push back
Variation 1	If the aircraft is calling too early for its slot, then replace step 3 with: 3.1 The Ground ATCO sees that the status of the flight in DMAN is not 'OK to push' 3.2 The Ground ATCO assesses the situation regarding workload and aircraft already remote holding



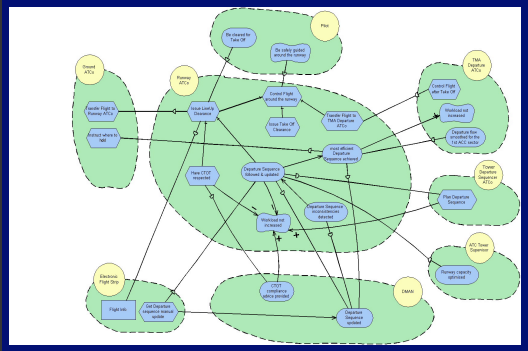
15 use cases, 13 normal course actions + 3 variations, on average

RESCUE: *i** System Modeling

SD and SR models, with REDEPEND tool



15 actors, 46 dependencies



For 7 actors, 103 model elements

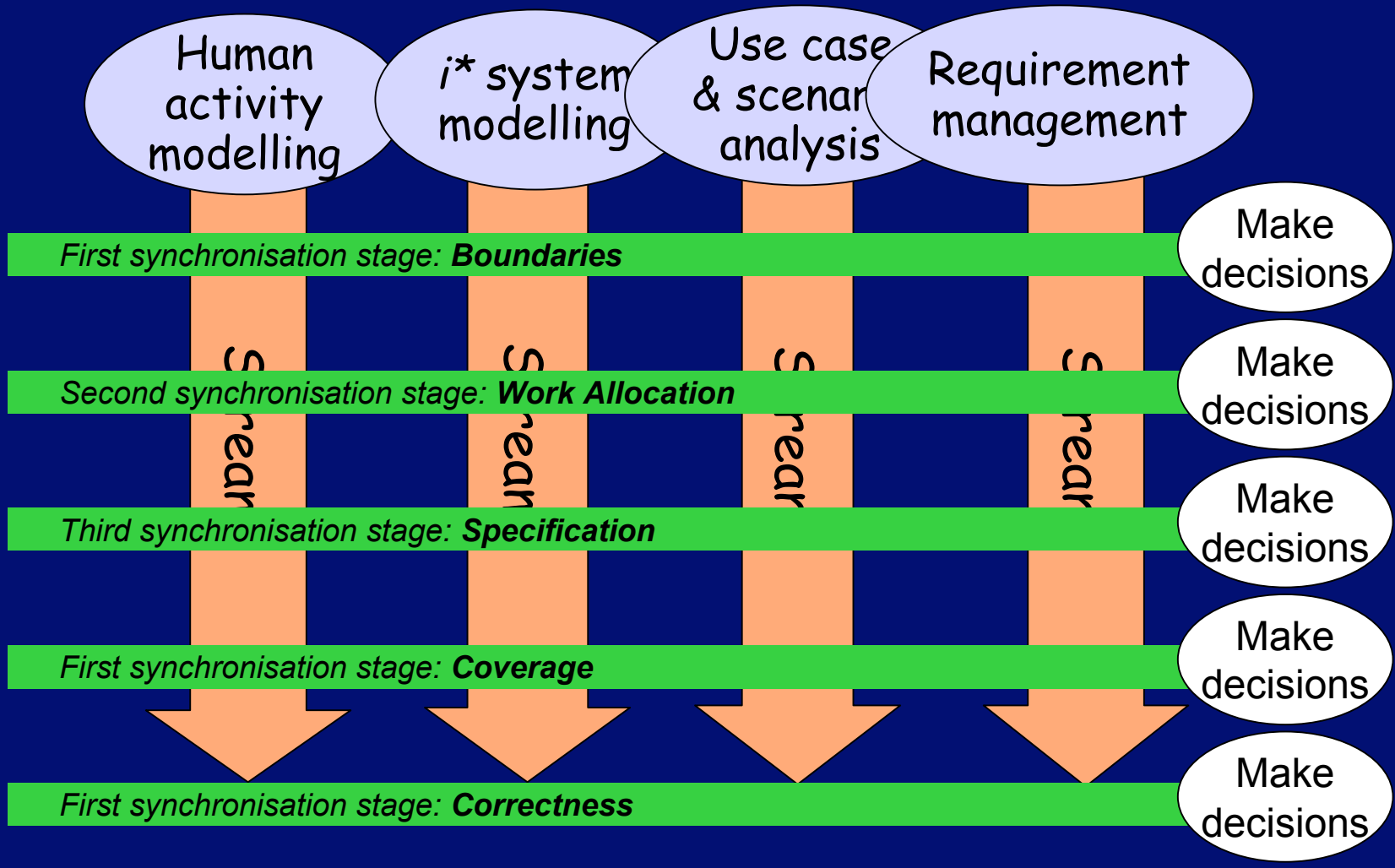
*i** Modeling: Lessons

Enhanced process guidance

- Extended context models prior to *i** system models

- Dependency tables prior to modeling
  - Controller depends on DMAN to depart aircraft on time
  - DMAN depends on controller to update departure schedule
- Guidelines to focus on goal/soft goal dependencies
- Simple-to-use plug-in to MS-VISIO

RESCUE: Five Synchronisation Stages



Some Synchronisation Checks

Stages 1 and 2: Boundaries and Work Allocation

Check	Definition
2.2	Actors, resources, goals, actions, differences due to variations, and differences due to contextual features in the activity models should appear in relevant use case descriptions.
2.4	All external actors in the i* SD model should correspond to actors in the use case descriptions.
2.5.1	Each low level task (i.e. each task that is not decomposed into further lower-level tasks) undertaken by an actor in the i* SR model, should correspond to one or more actions in a use case description.

DMAN Results

Synchronisation checks undertaken at each stage

- Stage 1: May 2003
- Stage 2: September 2003
- *Stage 3/4: January 2004*

Stage 1 and 2 checks

- RESCUE Quality Gatekeeper
- Results reported in detailed check-by-check reports

Results from Stages 1/2: Sept 2003

Quality Gatekeeper worked for 8 days

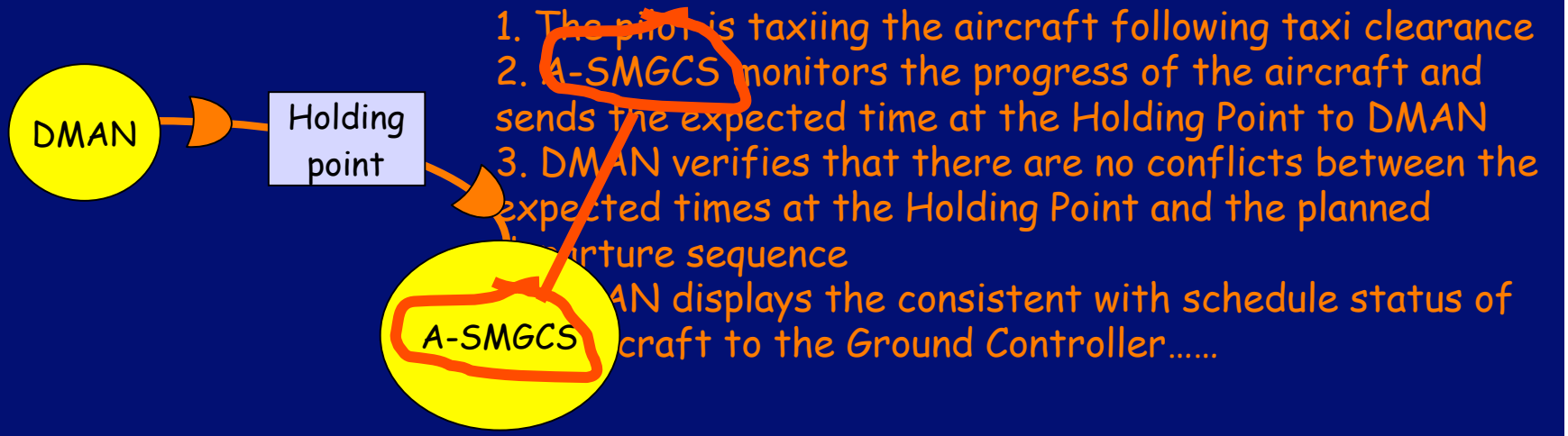
- 126 issues from 7 checks
- 113 of these from only 3 checks

Check	Total	Issues and actions
1.1	3	✔ Current system activities without use cases
1.2	4	✔ Current system actors missing from context model
1.3	21	✖ Context model actors and actor links missing from the use case model and, incorrect actor naming
2.2	1	✖ Ambiguity in use of contextual variations in use case descriptions detected
2.4	37	✖ *i** model actors missing from the use case descriptions
2.5.1	5	✖ *i** model tasks missing from the use case descriptions
2.5.3	55	✖ Ambiguities needing clarification, missing use case elements, dependencies between use cases discovered, use case decomposition needed, action ordering wrong, missing non-functional requirements

Check 2.4

Check 2.4 (37): Missing actors from UC descriptions

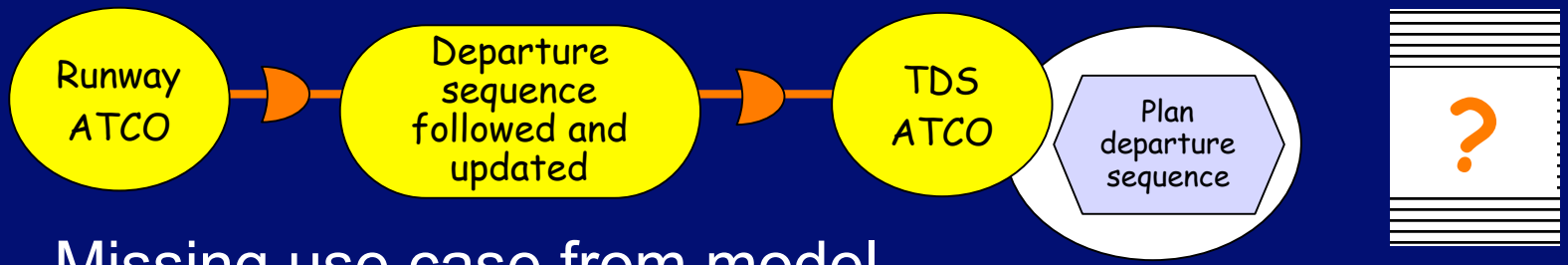
- Extend use case specifications for completeness



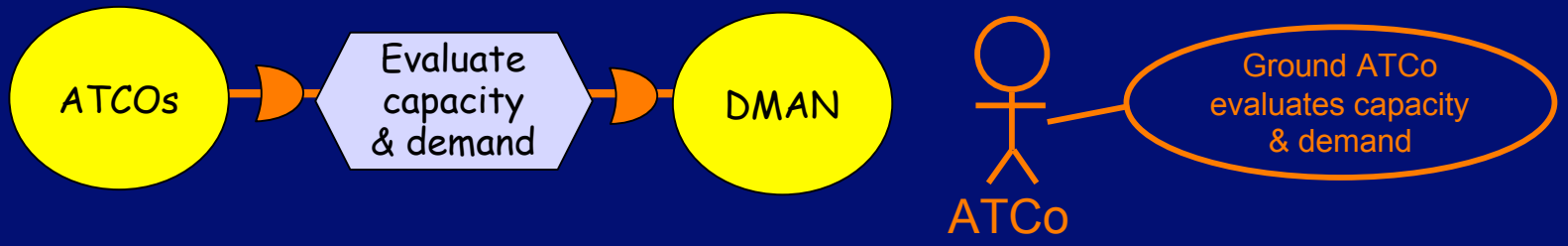
Check 2.5.3: *i** Dependencies in UC Descriptions

Revealed significant use case description omissions

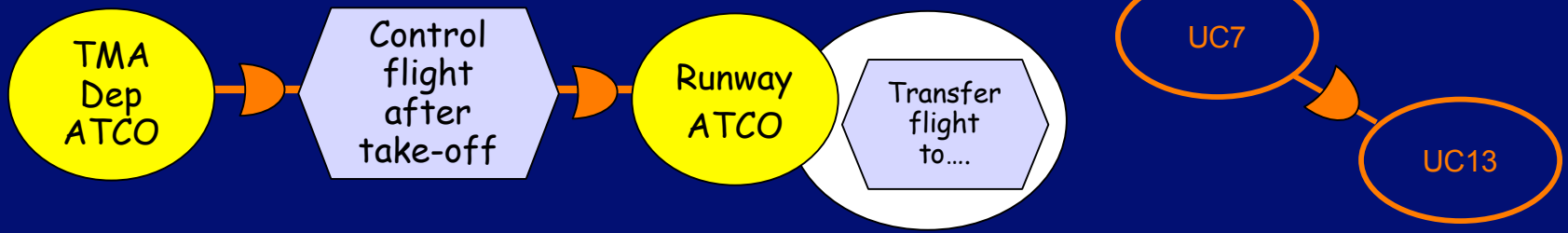
- Task descriptions missing from use cases



- Missing use case from model



- Uncovers use case dependencies



Synchronisation Check Consequences

Led to model and specification revisions

- More complete use case specifications
- More complete scenarios to walk through in ART-SCENE environment
- More complete requirement statements derived from improved *i** SD and SR models (Maiden et al. 2004)
- Demonstrated benefits of context-rich descriptions of current system

Led to wider consideration of time-specific concepts

- Event-driven departure management protocols

Two Research Challenges Revisited

Our research results can scale

- *i** modeling was tractable and useful, with tool support
- ART-SCENE scenario walkthroughs are cost-effective
- But long-term commitment was needed from us!

Synchronising different models

- Revealed important and new insights into a complex operational specification
- *i** models impact on other specification representations
- Human intervention to interpret

Repeat experience - EASM specification

- Introduce new collaborative tool to generate candidate issues