System Goal Modelling using the *i** Approach in RESCUE

Centre HCI Design

27th February 2003

Learning Objectives

Three key objectives

- Introduce system goal modelling
- Provide Eurocontrol staff with *i** skills
- To offer advice to Eurocontrol staff on how to avoid past pitfalls

Learning objectives for Eurocontrol team

- To understand this stream in the RESCUE process
- To understand and appreciate the need to model stakeholder goals/requirements
- To understand the basic *i** framework
- To be able to apply *i** key techniques
- To be able to develop simple *i** models using the REDEPEND software tool

Tutorial Timetable

A simple timetable

– Thursday 27th February 2003

Am: Background and overview
Determine system boundaries
Basic *i** syntax and semantics

Pm: Develop Strategic Dependency (SD) models
Use the REDEPEND tool

– Tuesday 25th March 2003

Am: Develop Strategic Rationale Models

Pm: Continue Strategic Rationale Models
Use the REDEPEND tool again

Running Examples

A range of examples in the tutorial

- Simple *internet airline ticketing system* example to demonstrate main concepts
- Simple *Motor insurance claim processing* example
- More complex *automated bus indicators* example to undertake and experiment with
- Real life examples included from CORA-2 project

Numerous short examples available to practice with

- *Automated rail ticketing system* example
- *Airport security system* example
- *Train signal* example
- *Automatic airline check-in* example

Part 1:

Background and Overview

Requirements Modelling Vs Description

- Requirements description
  - Informal requirements attributes and structures
  - Document-based, not amenable to automated analysis
    - For example, analysis checklists and interaction matrices (Sommerville & Kotonya 1998)
- Requirements modelling
  - Future system model, amenable to automated analysis
  - Models used to infer properties
    - Incomplete and inconsistent requirements, potential sources of problem in the new system, consequences of making decisions
  - Costs associated with requirements modelling

Modelling Requirements Dependencies

Stakeholder requirements are often conflicting

- No single socio-technical solution can satisfy them
- Requirements engineers often have to make complex trade-offs between requirements based on their priority, importance, risk, cost and time-to-deliver

Requirements dependencies are critical

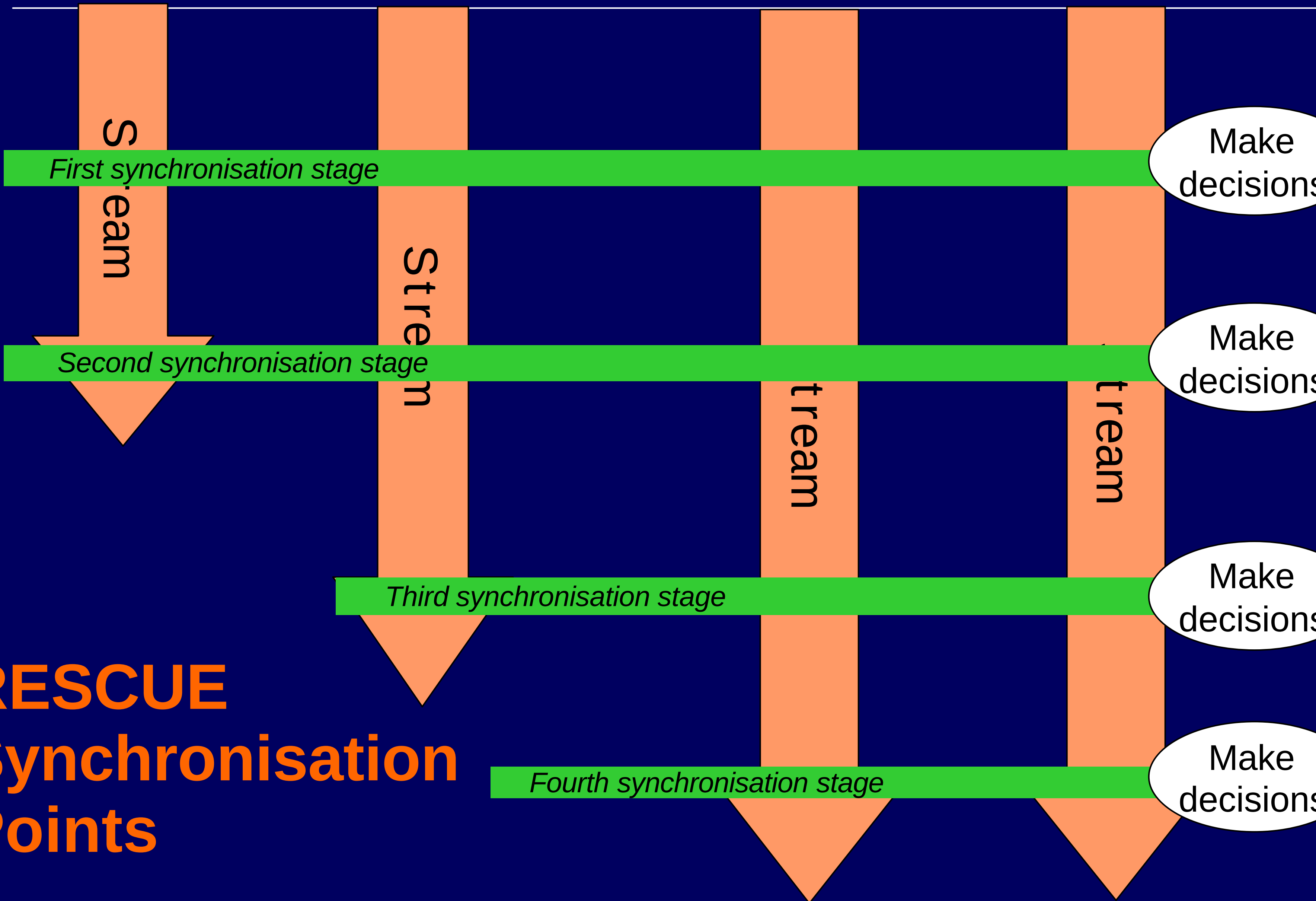
- To understand the important trade-offs to make
- Modelling requirements dependencies is the most important role of requirements modelling

Several available modelling approaches

- *i** goal modelling approach is one of the most established and effective

The *i** (Eye-Star) Goal Modelling Approach

- Requirements modelling and analysis
  - From research at the University of Toronto
    - PhD Thesis of Eric Yu (http://www.cs.toronto.edu/~eric/)
  - Syntax and semantics for modelling complex types of associations between requirements and other important concepts
- Extended to integrate with RESCUE
  - Process guidance for *i** system modelling
  - Cross-referencing *i** system models with other requirement models and descriptions
  - Software tool support for *i** modelling



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First synchronisation stage

Second synchronisation stage

Third synchronisation stage

Fourth synchronisation stage

Make decisions

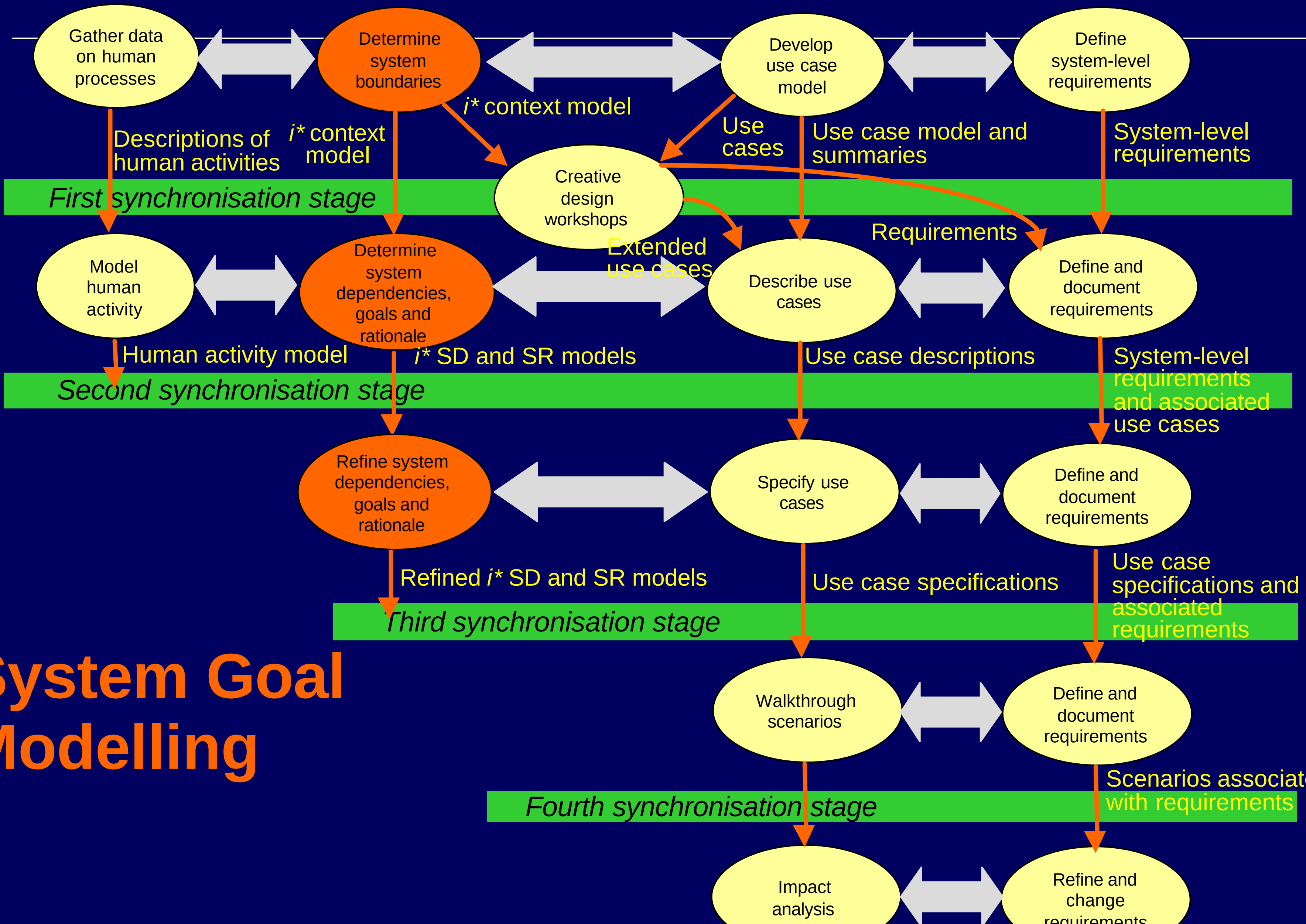
Make decisions

Make decisions

Make decisions

RESCUE Synchronisation Points

System Goal Modelling



Gather data on human processes

Determine system boundaries

Develop use case model

Define system-level requirements

*i** context model

Descriptions of human activities

*i** context model

Use cases

Use case model and summaries

System-level requirements

Creative design workshops

First synchronisation stage

Requirements

Extended use cases

Model human activity

Determine system dependencies, goals and rationale

Describe use cases

Define and document requirements

Human activity model

*i** SD and SR models

Use case descriptions

System-level requirements and associated use cases

Second synchronisation stage

Refine system dependencies, goals and rationale

Specify use cases

Define and document requirements

Refined *i** SD and SR models

Use case specifications

Use case specifications and associated requirements

Third synchronisation stage

Walkthrough scenarios

Define and document requirements

Scenarios associat

with requirements

Fourth synchronisation stage

Impact analysis

Refine and change requirements

System Modelling Stream Basics

Develop a Context Model

- – Establish the strategic actors (Context Diagram)

Develop a Strategic Dependency Model

- – Model requirements-related dependencies between strategic actors

Develop single Strategic Rationale Models

- – Model what each actor can accomplish itself
- – Model what each actor depends on other actors for

Develop integrated I* SD and SR models

- – Integrate the single-actor SR models
- – Model negative and positive links between requirements to explore requirements trade-offs

Part 2:

Determining System Boundaries

Setting the Context

Determine system boundary

- From experience - an agreed system boundary will improve the requirements process
- Different boundaries arise in most complex socio-technical systems

Determine strategic actors of system

- Actors can be human and/or adjacent systems
- People/systems who have an interest in the product - they will build it, manage it, use it, or in some way be affected by its use

Setting the Context

Simple system scoping

- – Use extended context data flow diagrams (DFDs) to indicate system boundary or system boundaries
- – Model states what systems and actors are outside the system or interest
- – Draw several system boundaries to indicate the differen social, socio-technical and technical systems, producing a simple onion model

Adjacent systems

- – Systems that supply the work (products or systems) with information, or receive information and services from the work (Robertson & Robertson 1999)
- – Useful for thinking about actors and their dependencies

Context Diagrams

Simple representation

- Useful to develop a first-cut context diagram
- Separates what the project team will design or redesign, and what is beyond its scope (and helps to obtain stakeholder agreement!)
- Provides the baseline for more complicated *i** SD mode and use case models

Notation to use

- Established data flow diagram (*DFD*) notation
- Circles define the future system to design/redesign
- Use arrows to indicate flow of data to and from the system from external actors

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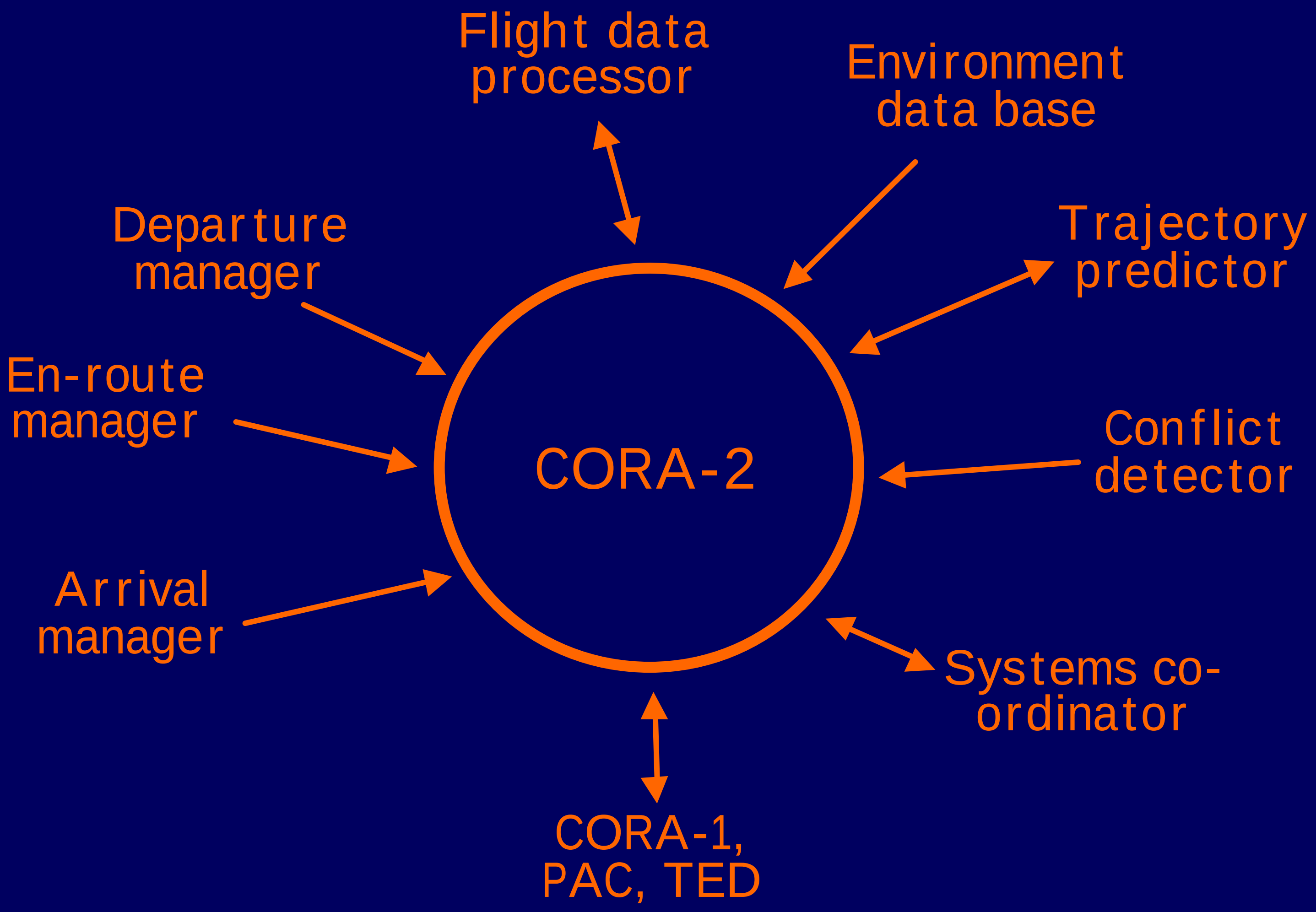
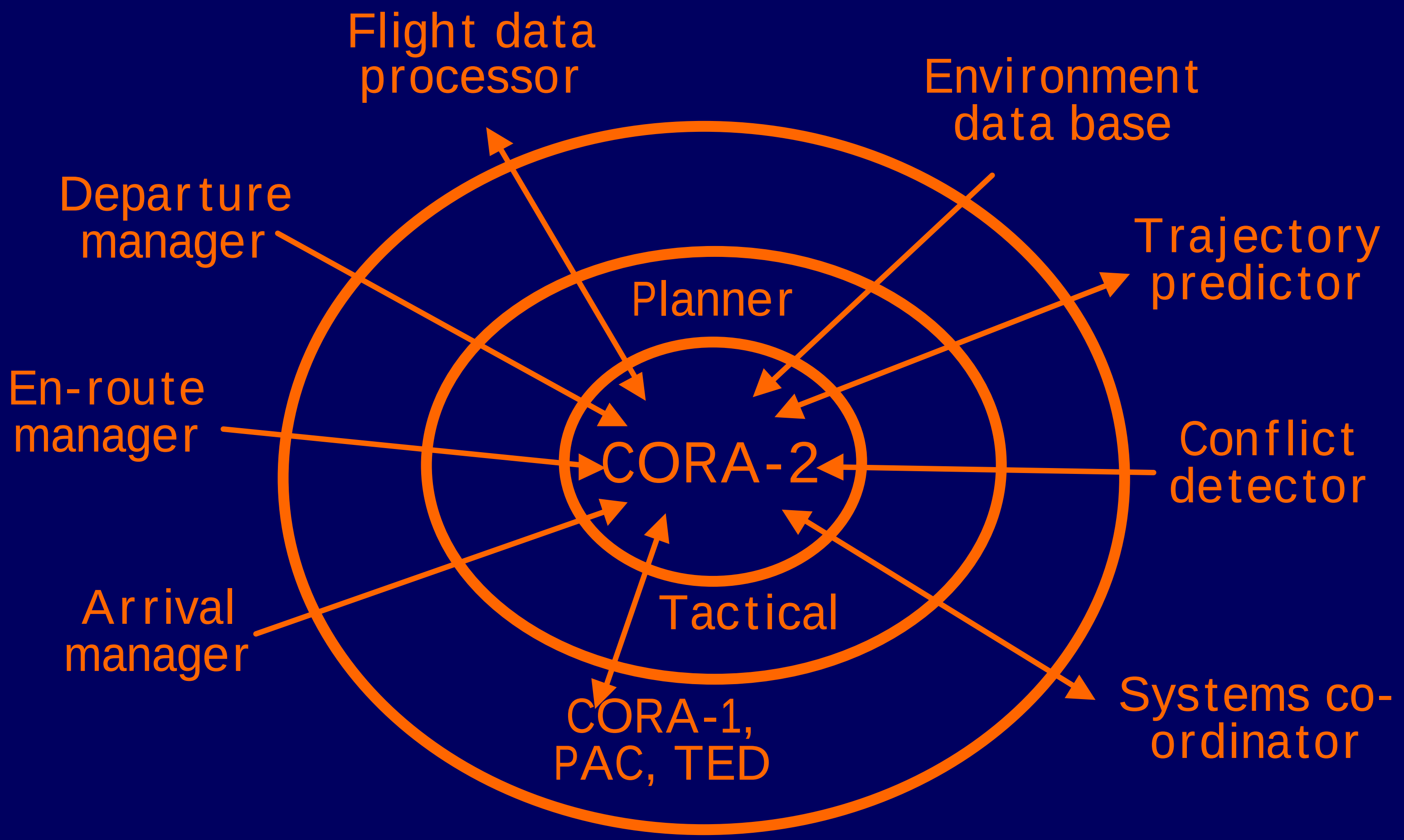
Example: Context Model for CORA-2



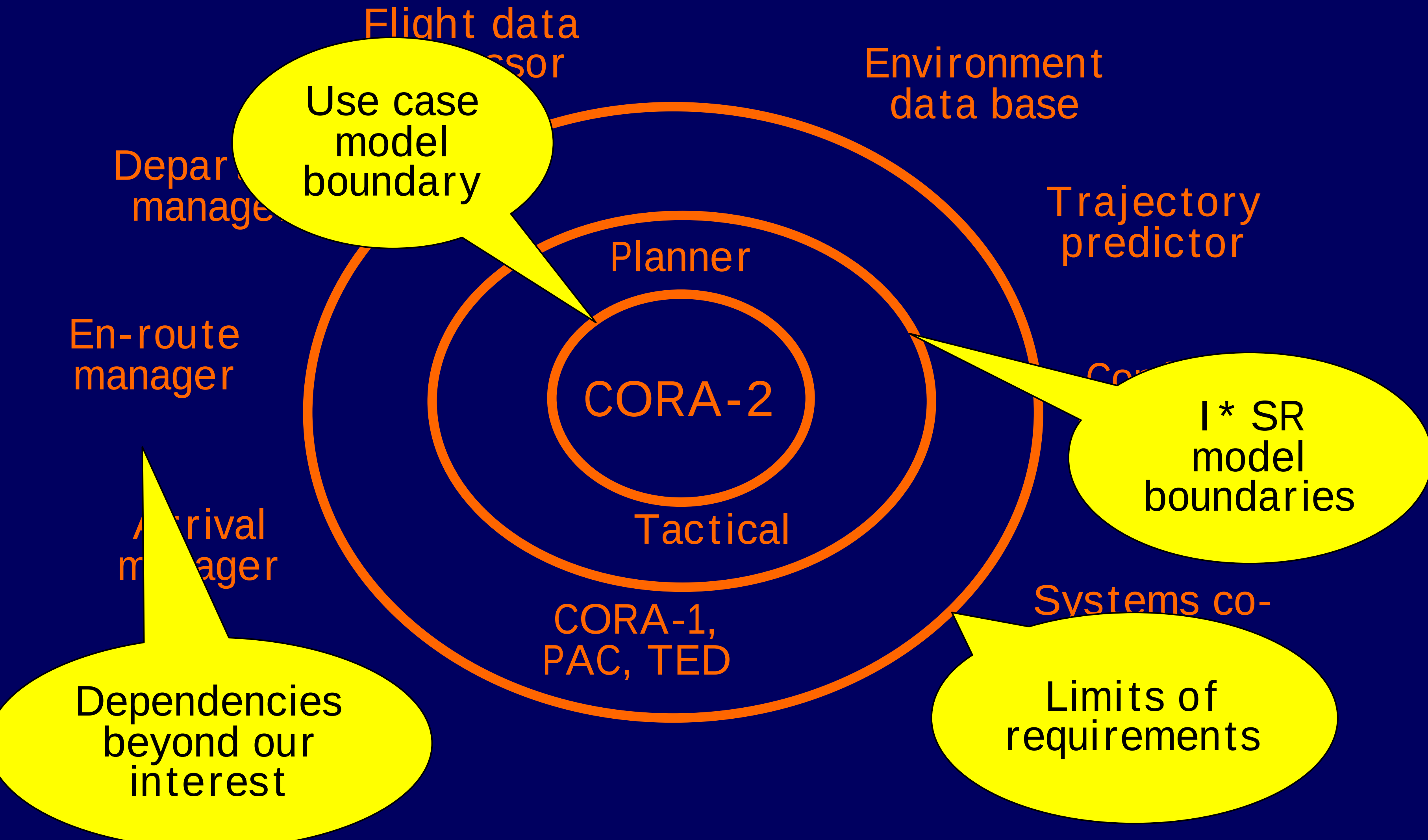
Indicate Different System Boundaries

- Computer-based systems to design or redesign
  - Main software development focus
  - These systems are often seen as the target systems
- Users whose work is being designed or redesigned
  - Primary users - their work is changed by the computerised system
  - Redesign their work as part of socio-technical system
- Existing systems or people influenced by system
  - Systems that will change to accommodate the new system and its users, but not dependent on it
- External systems that do not change
  - No consequences due to introduction of the new system

Example: Context Model for CORA-2



How Boundaries Relate to Other Models



Flight data ssor

Environment data base

Depar manage

Trajectory predictor

En-route manager

Con

A rival m ager

Systems co-

CORA-2

Planner

Tactical

CORA-1, PAC, TED

Use case model boundary

I* SR model boundaries

Dependencies beyond our interest

Limits of requirements

Modelling Actors

External systems, people and organisations

- Easier to recognise - adjacent systems tend to have well-defined boundaries
- Model roles of external people rather than people themselves - some people have different requirements depending on their role
- For example: radar, airlines, trajectory editor

Internal system roles

- Roles to be fulfilled by future system
- System modelling without design decisions
- More thorough actor model leads to more accurate requirements expression
- For example: planning and tactical controllers, conflict display device, controller communication mode

Model Adjacent Systems

Adjacent systems

- Systems that supply the work (products or systems) with information, or receive information and services from the work (Robertson & Robertson 1999)
- Useful for thinking about actors and their dependencies

Adjacent system characteristics give us 3 roles

- Active: Dynamic systems that initiate events to achieve some goal or purpose
- Autonomous: Independent systems that act independently
- Co-operative: Predictable systems that are used to bring about some desired outcome

Active Adjacent Systems

Dynamic systems

- Initiate events to achieve some purpose or goal

Common characteristics

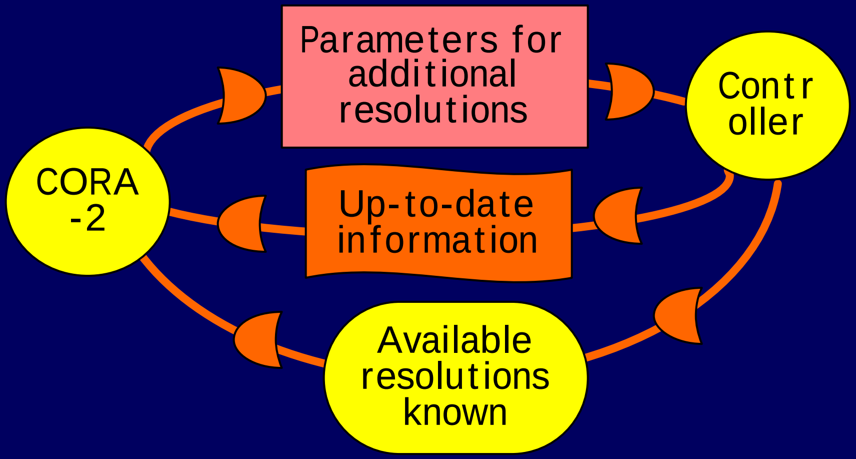
- Their behaviour is dynamic
- Able to interact with or participate in the work
- Are often human beings
- Initiate events to achieve purpose or goal
- Can predict this system’s behaviour (within reason)

Example

Customer

Example of an Active Adjacent System

From CORA-2


Parameters for additional resolutions
Controller
CORA -2
Up-to-date information
Available resolutions known

Question

- Why is the controller an active adjacent system?

Autonomous Adjacent Systems

- Independent systems
  - Act independently
- Common characteristics
  - Behave independently of other systems
  - Communicate through one-way data flows
  - Are often external bodies such as outside department, customers who do not direct interact with your system
- Examples

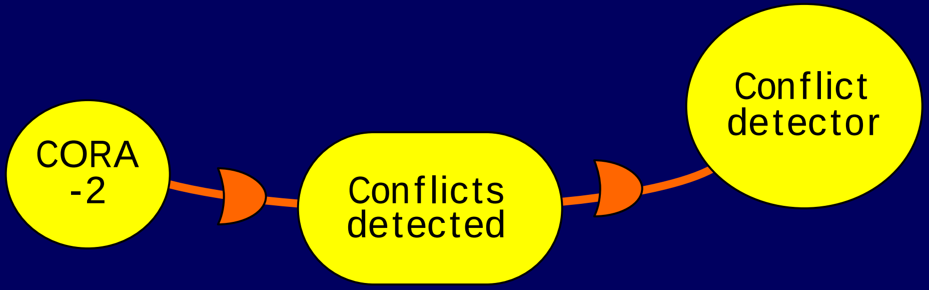
Airlin
e

NATS

Govt

Example of an Autonomous Adjacent System

From CORA-2



Question

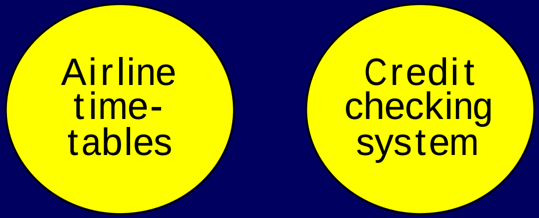
– Why is the conflict detectot an autonomous adjacent system?

Co-operative Adjacent Systems

Common characteristics

- Behaviour is predictable
- Communication achieved through simple request-response dialogues
- Co-operative systems often store data or provide predictable services - can be looked at as ‘black boxes’
- Typical examples other systems that contains a used database, an operating system, or a system that provides a documented and immediate services

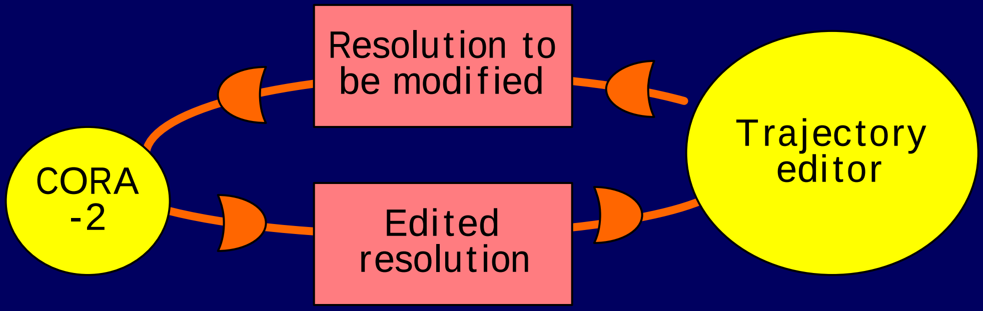
Examples


Airline time-tables

Credit checking system

Example of a Co-operative Adjacent System

From CORA-2



Question

– Why is the trajectory editor a co-operative adjacent system?

Cross Model Checks in RESCUE

Compare context model and use case model

- – Each actor in the use case model corresponds to one or more actors in the context model
- – The boundary in the use case model corresponds to the level-1 boundary in the context model

Compare context model and human activity model

- – Each actor in the human activity model corresponds to one or more actors in the context model
- – Each data flow in the human activity model corresponds to one or more data flows in the context model

Exercises:

Context Modelling

Motor Insurance Claim Processing

Learning objective

- To practice the development of context diagrams

Problem

- An insurance company wants to minimise payments to owners who claim. Specific repair body shops are hired to carry out repairs. The company also wants to keep car owners happy so that they renew their policies. One method used to keep customers happy is to offer courtesy cars to car owners who's cars are being repaired. The company is responsible for hiring the courtesy cars from a hire firm. The company must adhere to the standards set by its governing body.

Task

- Develop a simple context diagram

Automated Bus Indicators

Learning objective

- To practice the development of context diagrams

Problem

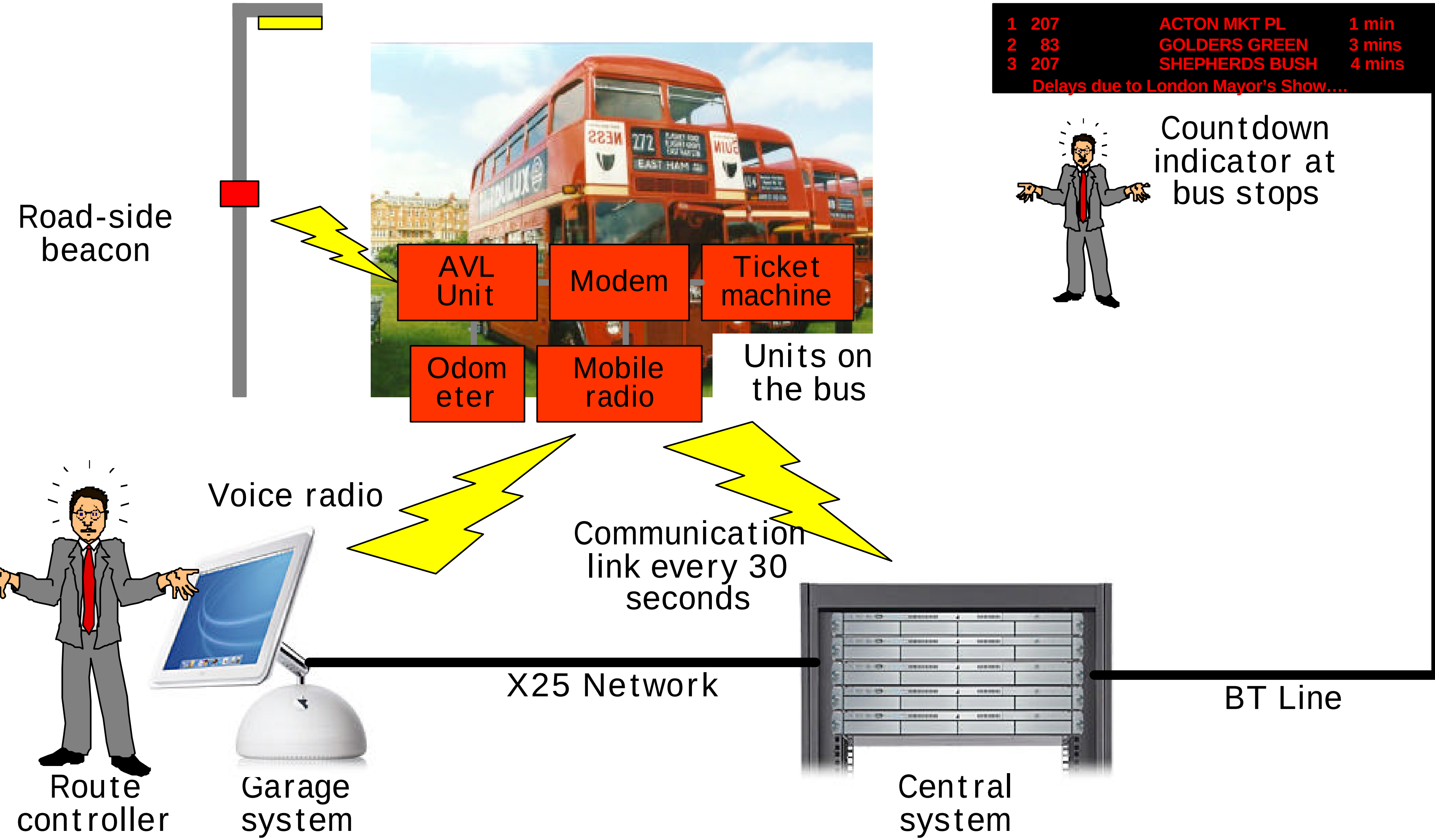
- Countdown is the new scheme being implemented by London Buses across London. It is designed to remove one of the principal deterrents to bus travel – uncertain waiting times. You might have seen the digital displays at bus stops – Countdown carries a number of pieces of information to waiting passengers in a clear, easy-to-understand form.

1	207	ACTON MKT PL	1 min
2	83	GOLDERS GREEN	3 mins
3	207	SHEPHERDS BUSH	4 mins

……Delays due to London Mayor’s Show

Task

- Define the key strategic actors
- Sketch first-cut context diagram



1	207	ACTON MKT PL	1 min
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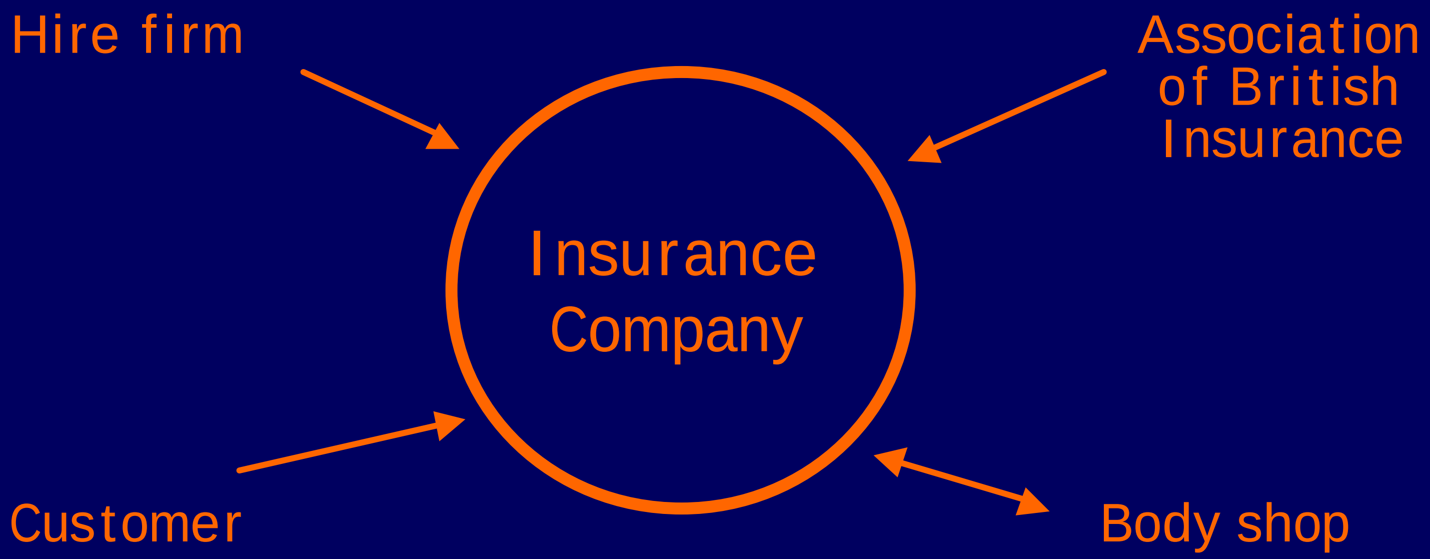
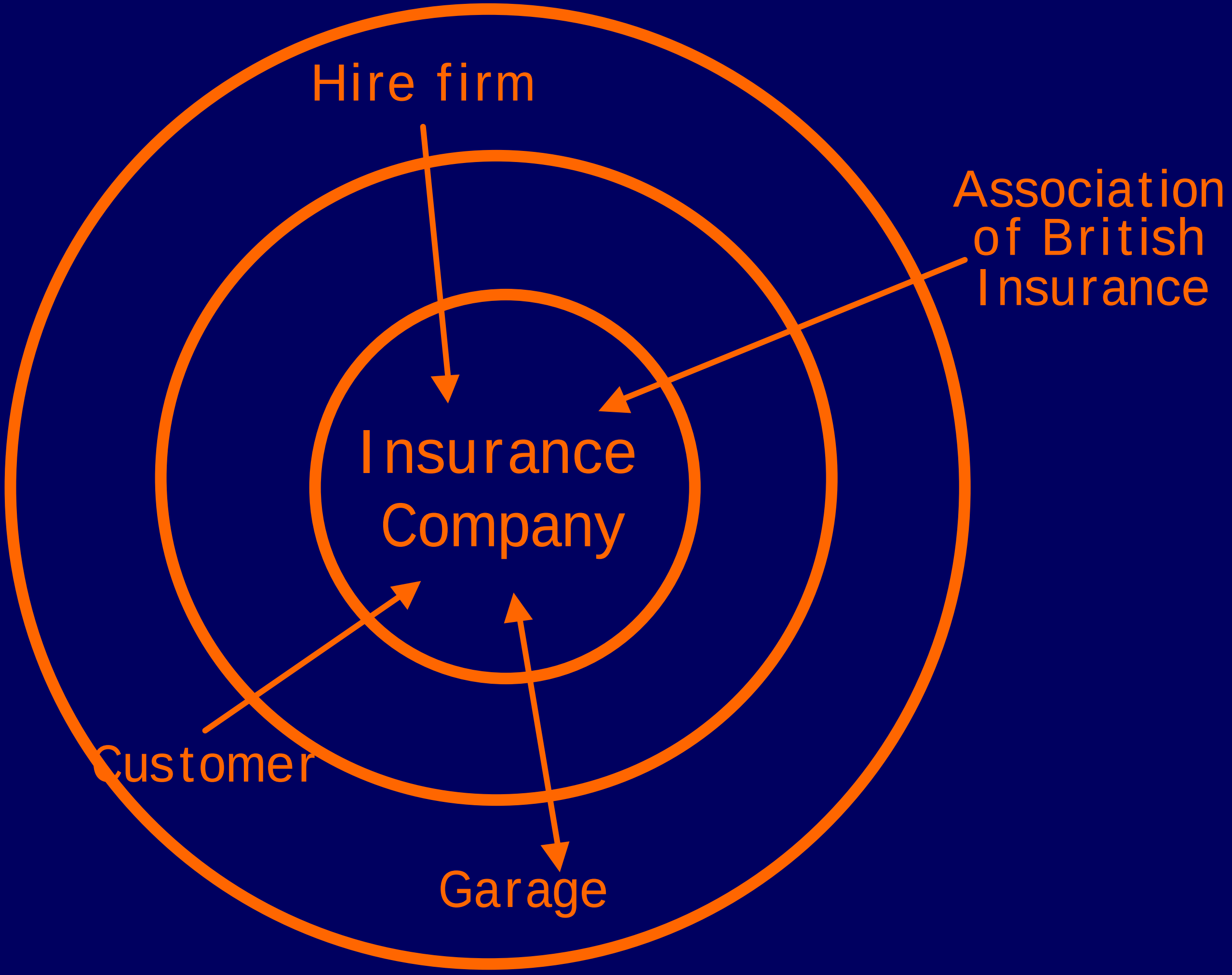
Delays due to London Mayor's Show….

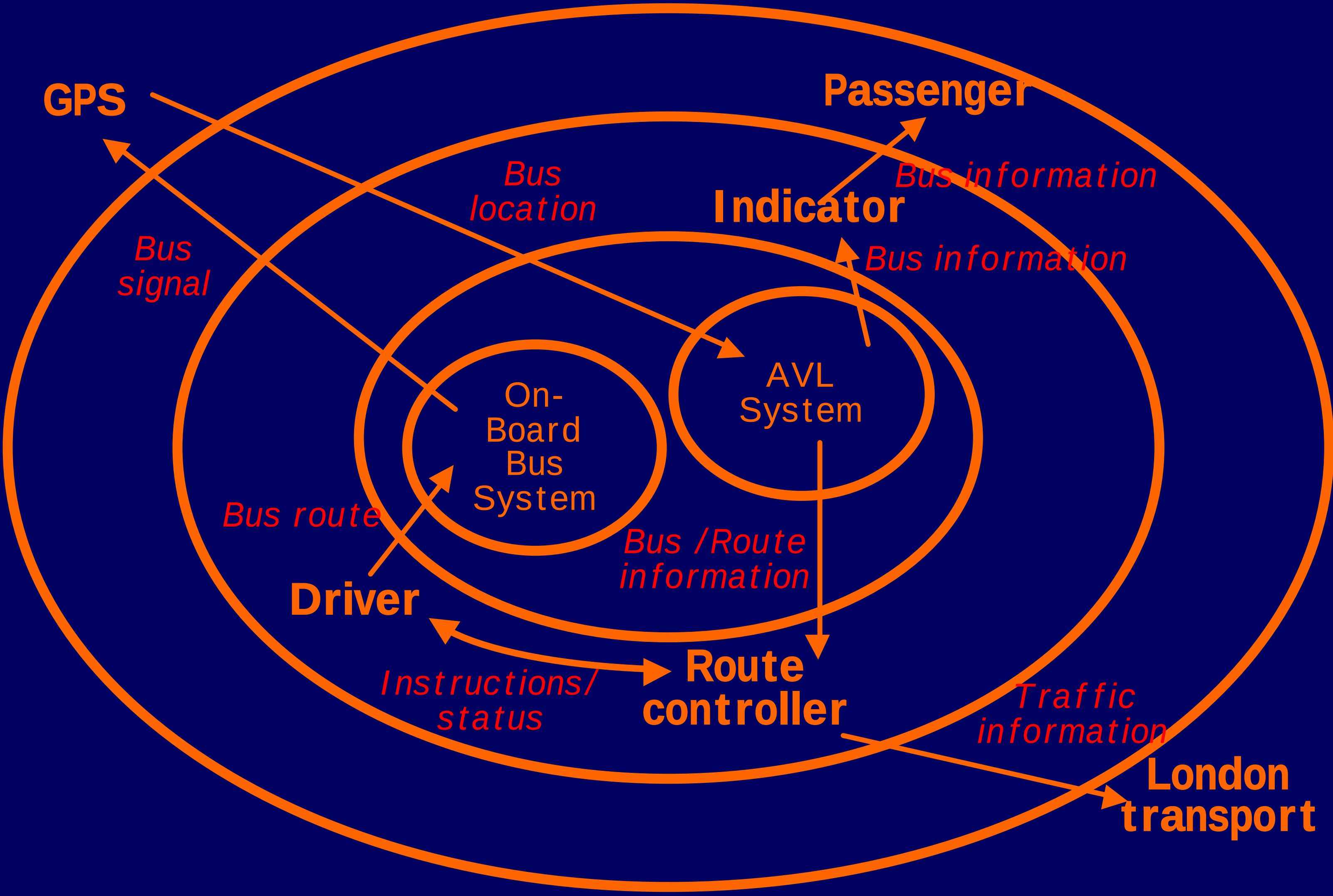
Context Diagram for Motor Insurance



Context Diagram for Motor Insurance



Context Diagram for Countdown



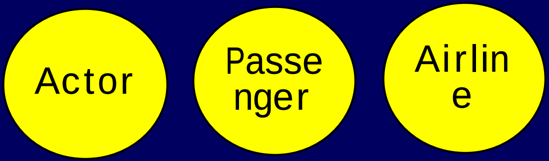
Part 3:

Developing a Strategic Dependency Model

*i** Modelling Basics

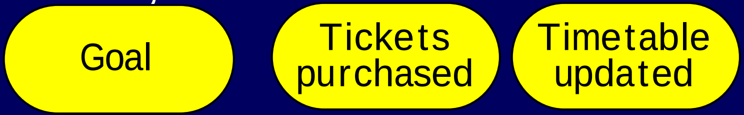
Key modelling semantics

- Intentional strategic actor



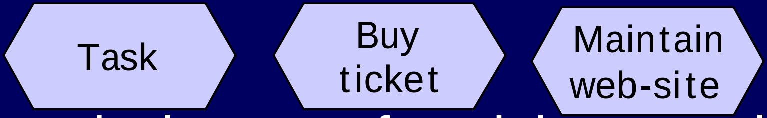
  - Intentional aspects such as objectives, rationale & commitments

- Goal (functional requirement)



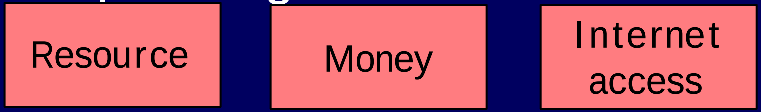
  - Condition or state of the world that can be achieved or not

- Task



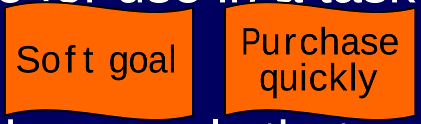
  - One particular way of attaining a goal - a detailed description of how to accomplish a goal

- Resource



  - Physical or informational objects in the world availability (e.g. the finished product of some action) available for use in a task

- Softgoals (non-functional requirements)



  - Goals that cannot be so sharply defined, such as goals that describe properties or constraints of the system being modelled

Some Words About Actors

Actors include the new system to introduce

Actors include actor roles

- A single user/adjacent system can instantiate several different actors
- Same actors can have different goals or requirements depending on their role
- Understanding different roles provides a deeper understanding of the context
- Important to make distinction between the roles of actors in the *i** SD model

Returning to our airline ticketing example

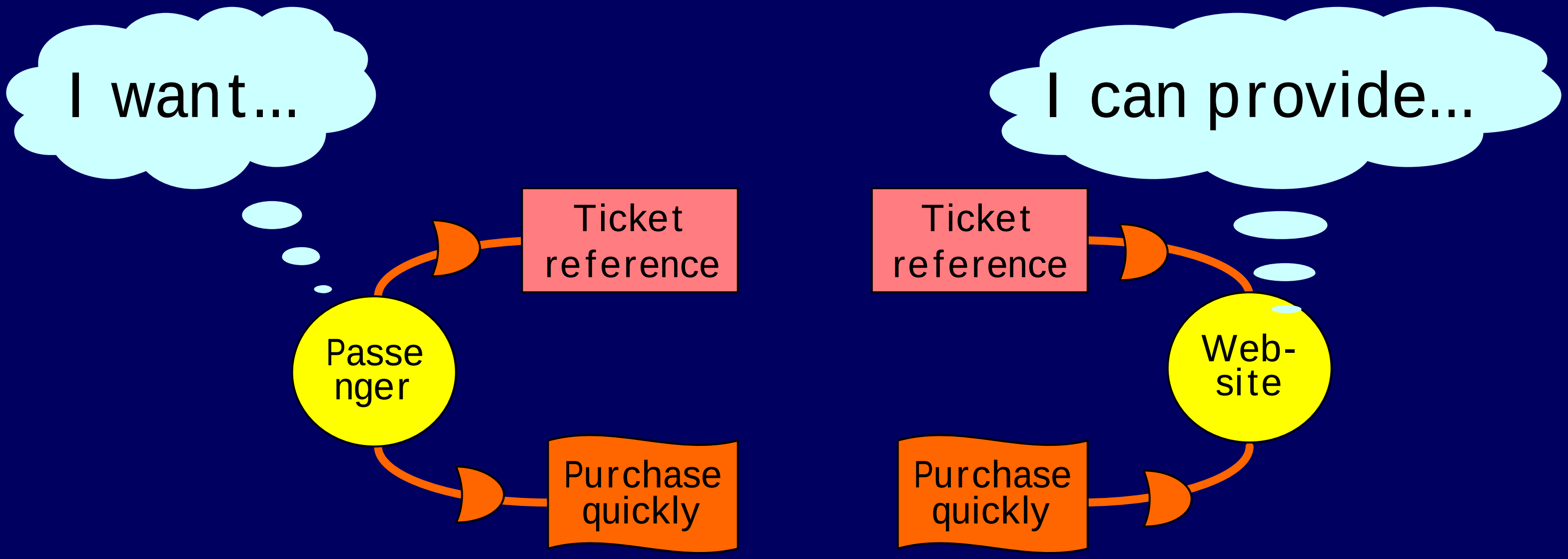
- A passenger can fulfil several roles

Purchaser
Complainant
Traveller

Strategic Dependencies

Developed from the context model

- Describes the network of relationships and dependencies among strategic actors
- Opportunities available can be explored
- Matching the depender who is the actor who “wants” and the dependee who has the “ability”



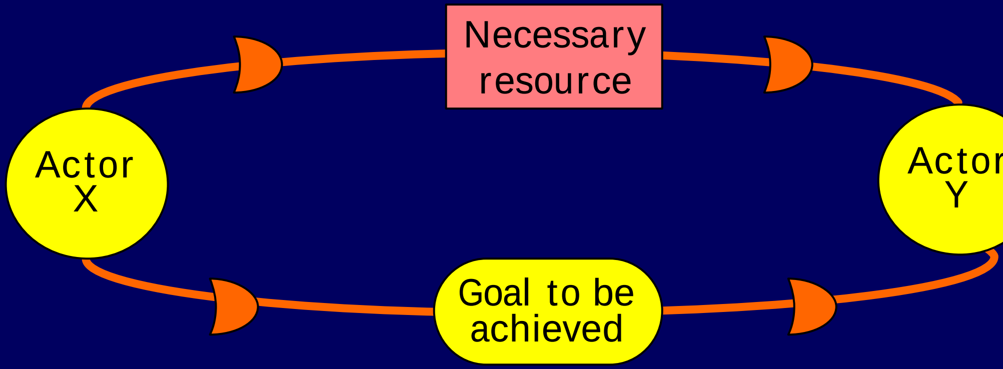
Strategic Dependency Modelling Cont.

Network of dependency relationships among actors

- Depender who is the actor who “wants” something
- Dependee who has the “ability”to do that something

Dependency relationships

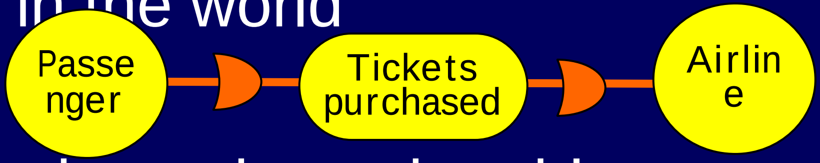
- Actor X is dependent on actor Y for obtaining a resource
  - The letter 'D' on the dependency link is oriented from X to Y
- Actor Y is dependent on actor X for achieving a goal
  - The letter 'D' on the dependency link is oriented from Y to X



Four Dependency Relationship Types

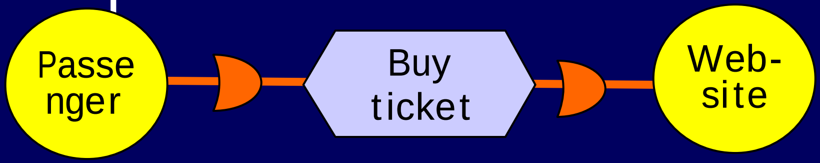
Goal Dependency

- Depender depends upon the dependee to be able to bring about certain state in the world



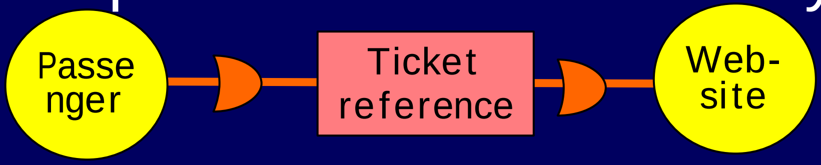
Task Dependency

- Depender depends upon dependee to be able to carry out task



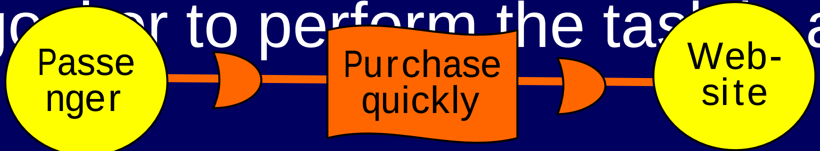
Resource Dependency

- Depender depends upon dependee for the availability o entity



Softgoal Dependency

- Depender depends upon dependee to perform some task that meets the softgo r to perform the tas a particular way.



Strategic Dependency (SD) Modelling

Network of dependency relationships among actors

- Depender who is the actor who “wants” something
- Dependee who has the “ability” that something

Explore first of all using dependencies tables

Subject		Noun	Dependency
Agent	depends on	Agent	for something
Pilot	depends on	Controller	to be safe (SG)
Pilot	depends on	Controller	for instructions (R)
Controller	depends on	Pilot	to redirect aircraft (T)
Student	depends on	Neil	to learn well (SG)
Neil	depends on	Student	to deliver lecture (T)
Customer	depends on	Airline	to have tickets bought (

Heuristics for Modelling Dependencies

*i**+ heuristics to guide dependency modelling

- Model dependencies between local actors - treat them as transitive, and avoid modelling duplicate dependencies
- Boundaries - if depender goals and soft goals to be tested for compliance, then actor is part of the socio-technical system
- Depender always initiates and owns the task
- Where possible, transform task- and resource-type dependencies into goal- and soft-goal-type dependencies by asking why does the depender need to undertake the task or have the resource?
- Model task-type dependencies if there are different ways of achieving a goal - otherwise model goal-type dependencies

Exercise:

*i** Strategic Dependency Modelling

Motor Insurance Claim Processing

Learning objective

- To practice the identification of dependencies

Problem (as above)

- An insurance company wants to minimise payments to owners who claim. Specific repair body shops are hired to carry out repairs. The company also wants to keep car owners happy so that they renew their policies. One method used to keep customers happy is to offer courtesy cars to car owners who’s cars are being repaired. The company is responsible for hiring the courtesy cars from a hire firm. The company must adhere to the standards set by the governing body.

Task

- Write simple dependency sentences

Automated Bus Indicators

Learning objective

- To practice the identification of dependencies

Problem

- Countdown is the new scheme being implemented by London Buses across London. It is designed to remove one of the principal deterrents to bus travel – uncertain waiting times. You might have seen the digital displays at bus stops – Countdown carries a number of pieces of information to waiting passengers in a clear, easy-to-understand form.

Task

- Write some simple sentences about the dependencies between different actors in the domain

Insurance Claim Dependencies

Subject		Noun	Dependency
Car owner	depends on	Insurance co	to be covered (G)
Car owner	depends on	Insurance co	to be processed quickly (S)
Car owner	depends on	Insurance co	to claim payment (T)
Insurance co	depends on	Car owner	to receive honest claims (S
Insurance co	depends on	Car owner	to have happy customers (S
Car owner	depends on	Garage	to have car repaired (G)
Car owner	depends on	Garage	to have repair quickly (SG)
Garage	depends on	Insurance co	to be listed garage (G)
Garage	depends on	Insurance co	for repair costs (R)
Insurance co	depends on	Garage	to keeps costs low (S)
Insurance co	depends on	Hire firm	to have regular vehicles (G)
Insurance co	depends on	Hire firm	to have happy customers (S
Hire firm	depends on	Insurance co	to have repeat business (S)
Hire firm	depends on	Insurance co	to maximise income (S)
Association	depends on	Insurance co	to maintain standards (S)
Insurance co	depends on	Association	to be member of Assoc. (G

Guidelines for Wording *i** Dependencies

- Goals
  - Wording of goals should describe a desirable state
    - *<desirable state>: Ticket purchased, car repaired*
- Soft goals
  - Describe some properties or constraints on that state
    - *<desirable state> <adjective | adverb>: Ticket purchased quickly, car repaired cheaply*
- Tasks
  - Active verbs describing how something is done
    - *<do task>: Purchase tickets online*
- Resource
  - Noun describing resource
    - *<resource>: Conflict information, 5 seconds, ticket*

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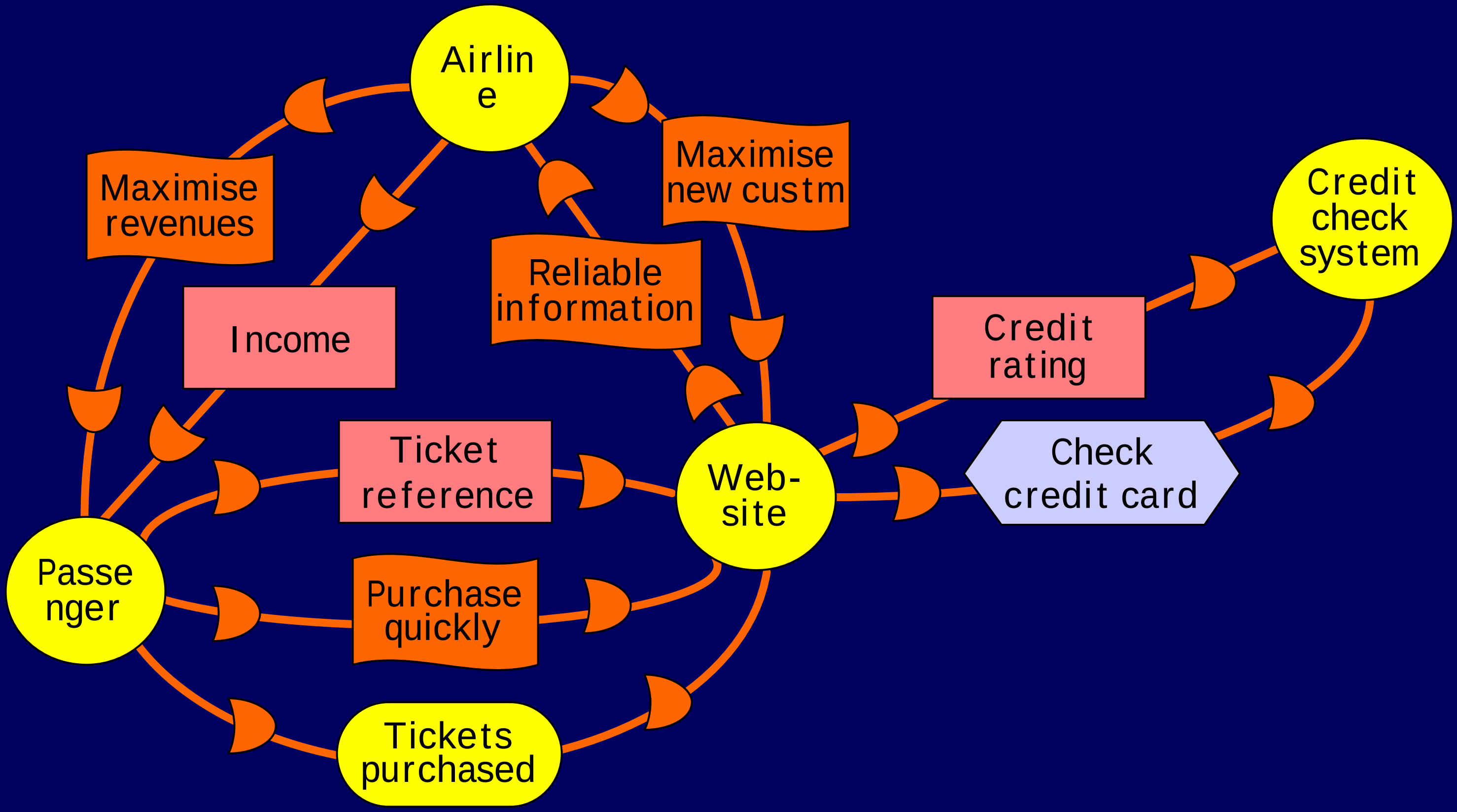
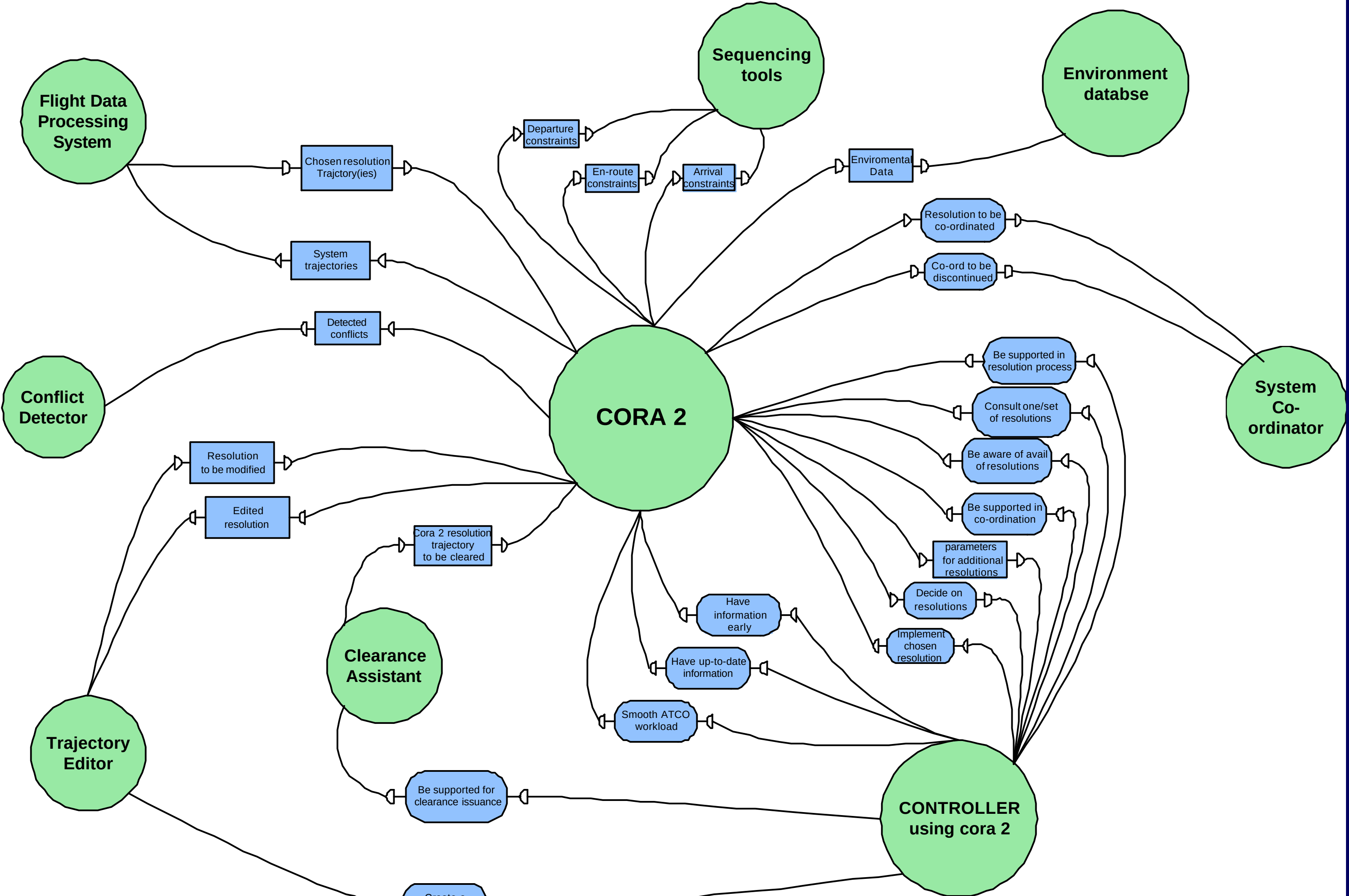
Put It All Together in a Model

For Internet Airline Ticketing System



Think about clusters of dependencies

CORA-2: Strategic Dependency Model



Flight Data Processing System

Sequencing tools

Environment databse

Departure constraints

En-route constraints

Arrival constraints

Chosen resolution Trajctory(ies)

Enviromental Data

System trajectories

Resolution to be co-ordinated

Co-ord to be discontinued

Detected conflicts

Conflict Detector

CORA 2

System Co-ordinator

Be supported in resolution process

Consult one/set of resolutions

Be aware of avail of resolutions

Be supported in co-ordination

parameters for additional resolutions

Decide on resolutions

Implement chosen resolution

Resolution to be modified

Edited resolution

Cora 2 resolution trajectory to be cleared

Have information early

Have up-to-date information

Smooth ATCO workload

Clearance Assistant

Trajectory Editor

Be supported for clearance issuance

CONTROLLER using cora 2

Create a

Cross Model Checks in RESCUE

Cross-model checks at this stage

- Compare *i** SD model and activity models to check that goals, resources, constraints and context in activity modelling appear, where relevant, in i* SD model
- Compare *i** SD model and use case model to check that the external actors in *i** SD model are equivalent to the external actors in use case model
- Also check that each task dependency in the *i** SD model has a corresponding use case in use case model
- Compare *i** SD model and system-level and use case requirements to check that each goal and soft-goal that the future system achieves (according to the *i** SD model) is described in the system requirements specification and stored in the requirements data base

Exercise:

*i** Strategic Dependency Modelling

Motor Insurance Claim Processing

Learning objective

- To practice producing the Strategic Dependency model

Problem (as above)

- An insurance company wants to minimise payments to owners who claim. Specific repair body shops are hired to carry out repairs. The company also wants to keep car owners happy so that they renew their policies. One method used to keep customers happy is to offer courtesy cars to car owners who’s cars are being repaired. The company is responsible for hiring the courtesy cars from a hire firm. The company must adhere to the standards set by the governing body.

Task

- Produce a Strategic Dependency model

Automated Bus Indicators

Learning objective

- To practice producing the Strategic Dependency model

Problem

- Countdown is the new scheme being implemented by London Buses across London. It is designed to remove one of the principal deterrents to bus travel – uncertain waiting times. You might have seen the digital displays at bus stops – Countdown carries a number of pieces of information to waiting passengers in a clear, easy-to-understand form.

Task

- Produce a Strategic Dependency model

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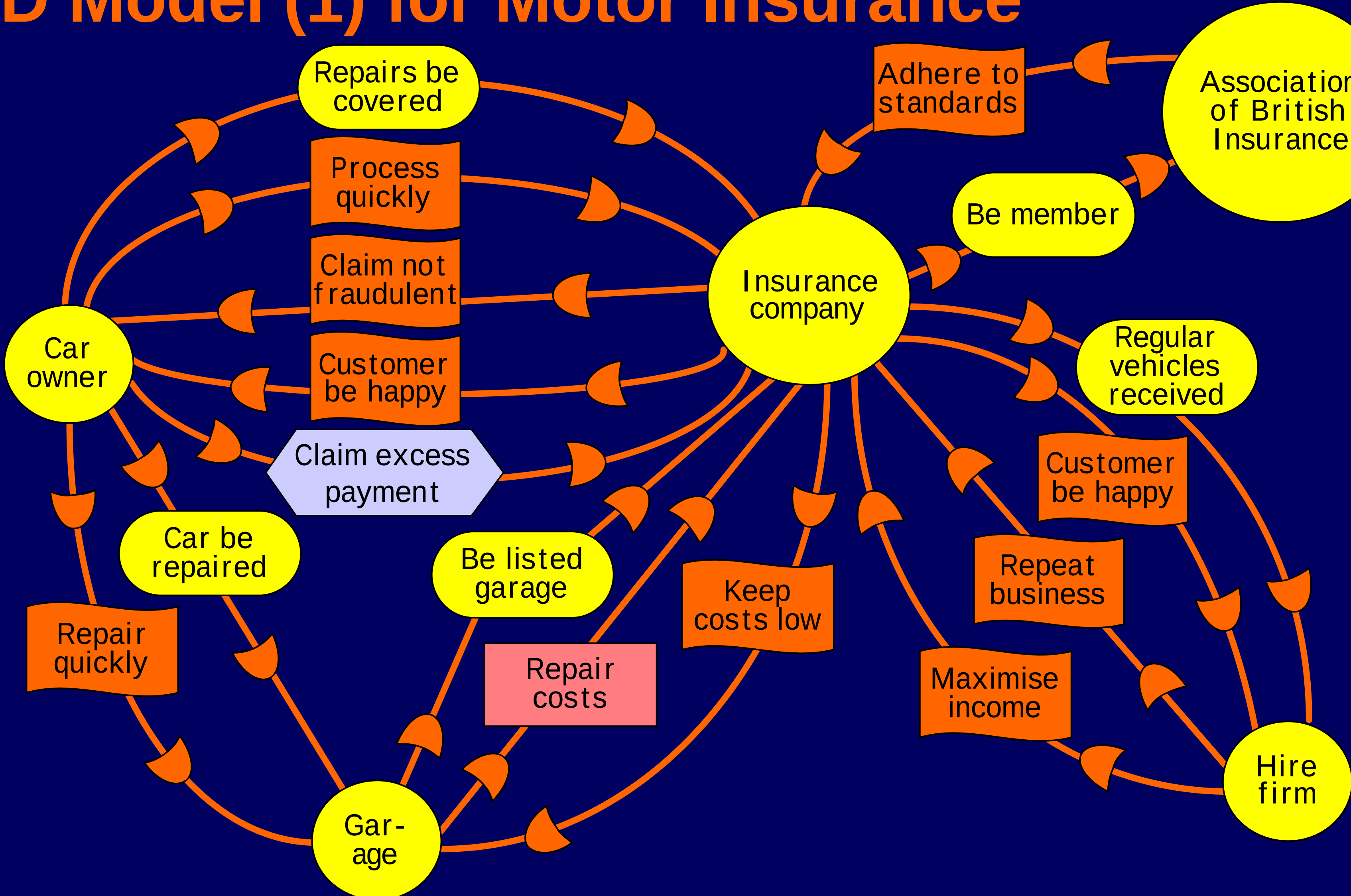
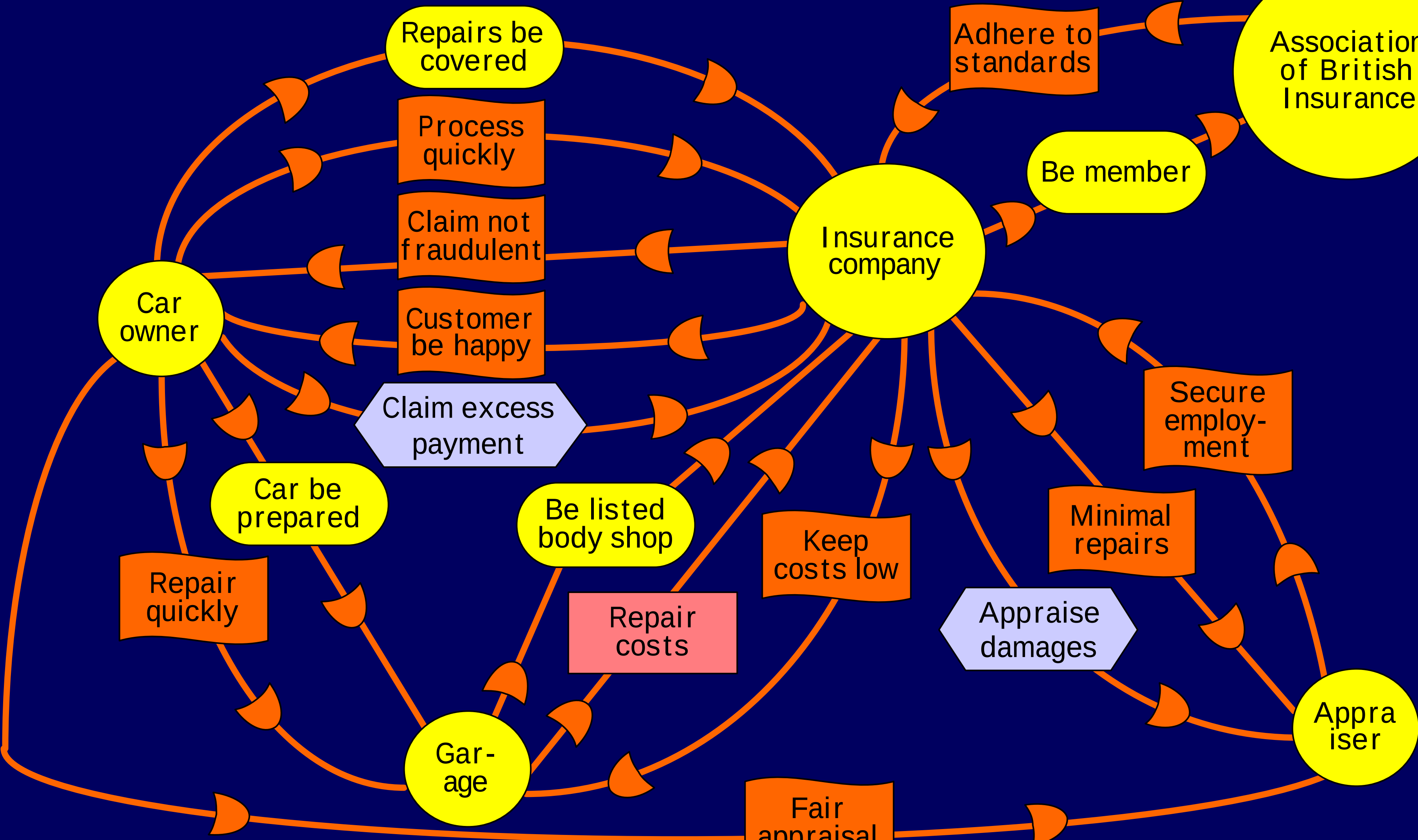
SD Model (1) for Motor Insurance



SD Model (2) for Motor Insurance



Summarising Context and SD Modelling

Part of the RESCUE Boundaries stage

- Model system boundaries in terms of actors, data flows between, and dependencies between actors
- *i** modelling is not an end, but a means to explore, analyse and negotiate system boundaries
- Spend time exploring boundaries - you will need this platform to specify requirements effectively

How to proceed

- Practice, practice, practice
- *i** modelling takes some practice, but applied proficiently, it is a very useful technique