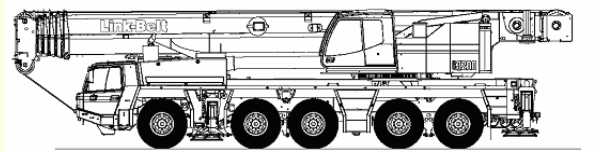# Query Based UML Modeling

Validation and Verification of the System Model and Behavior for a Hydraulic Crane

Denny Mathew

ENPM 643

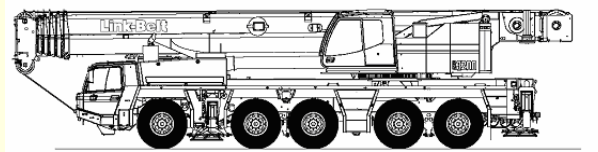**Instructor: Dr. Mark Austin**

Systems Engineering Process for a Hydraulic Crane

- Link Belt ATC 3200

- Requirements

- Systems Structure

- System Behavior

- Constraints

- System Allocation

- Verification

UML Query Tool
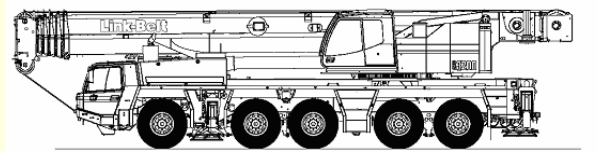
- Validation

- Query Modeling

Five Operational Phases of a Crane

- Pre-Start Initiation

- Handling and Attaching the Load

- Lifting the Load

- Maneuvering the Load

- Ending Lifting
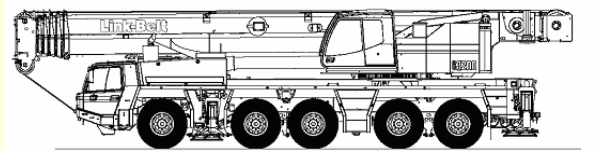

Nominal and Off-Nominal Use Cases in UML *

- Nominal: positive use cases

- Of-Nominal: negative use cases

* *Reference – Uchitel Implied-Scenario*
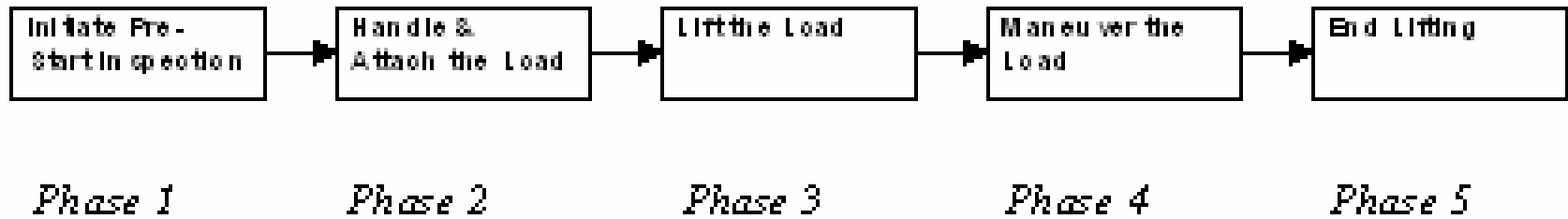
Constraints and Assumptions

- Crane Type: Only all-terrain mobile cranes are considered for this report.
- Risk: Only safety-related risks are evaluated and analyzed for the failure analysis.
- Operation: Only stationary crane operations are considered for this report.
- Analysis: The level of analysis for this case study is constrained at the operational level.

Operational Sequence

Initiate Pre-Start Inspection	Handle & Attach the Load	Lift the Load	Maneuver the Load	End Lifting
Phase 1	*Phase 2*	*Phase 3*	*Phase 4*	*Phase 5*

Class Diagram


```
                          CRANE
                            |
   ┌──────────┬──────────┬──────────┬──────────┬──────────┐
   │          │          │          │          │          │
  Boom    Counterweight  Rotex Gear  Boom Level  Clutch   Joystick
                                     Indicator
  Lift()   Tipping()    Rotation()   Load Limit() Brake()  Position()
           Support()                                       Balance()
   │          │
   ▼          ▼
 Reinforced   Jib
 Steel Cable
 Lift()       Support()
   │          │
   ▼          ▼
 Hook       Outrigger
 Attach()   Balance()
 Lift()     Support()
```
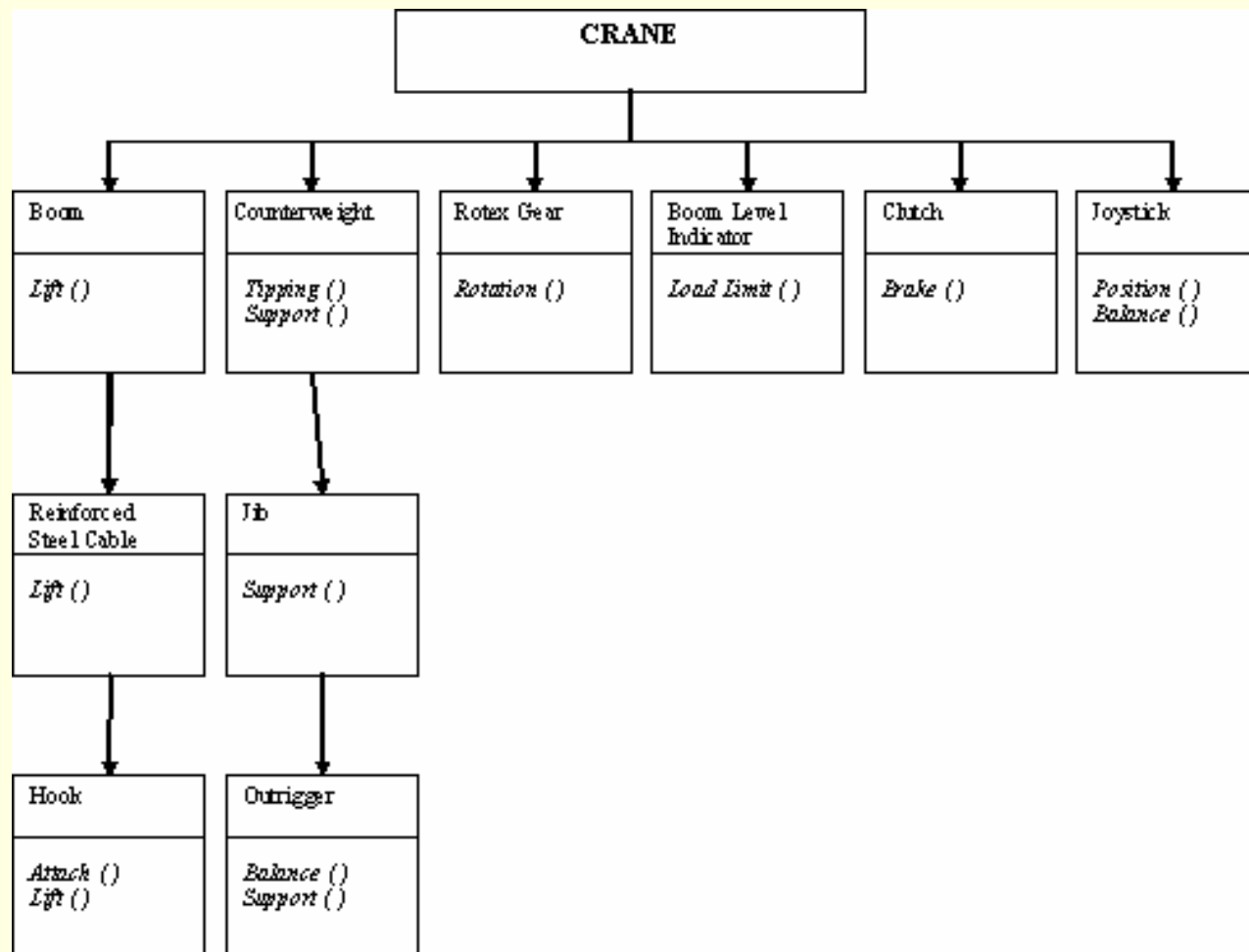
Inheritance Diagram

CRANE MAIN SYSTEM	
ATTRIBUTES	**FUNCTIONS**
Boom Length Hook Strength	Pre-Start Initiation
Counterweight Clutch Integrity	Handle and Attach
Rotex Gear Strength Joystick Movement	Lift
Jib Length	Maneuver
Outrigger Integrity	End Lift
Boom Level Indicator Integrity	
Cable Strength	

CRANE SUBSYSTEM	
ATTRIBUTES	**FUNCTIONS**
Guard Integrity Drum Integrity	Pre-Start Initiation
Turntable Movement Motion Control Movement	Handle and Attach
Tire Pressure Hydraulic Pump Pressure	Lift
Hydraulic Cylinder Leakage	Maneuver
Hydraulic Filter Integrity	End Lift

Initial Use Case Diagram

ACTOR
Crane Operator
Signalman
Oilman

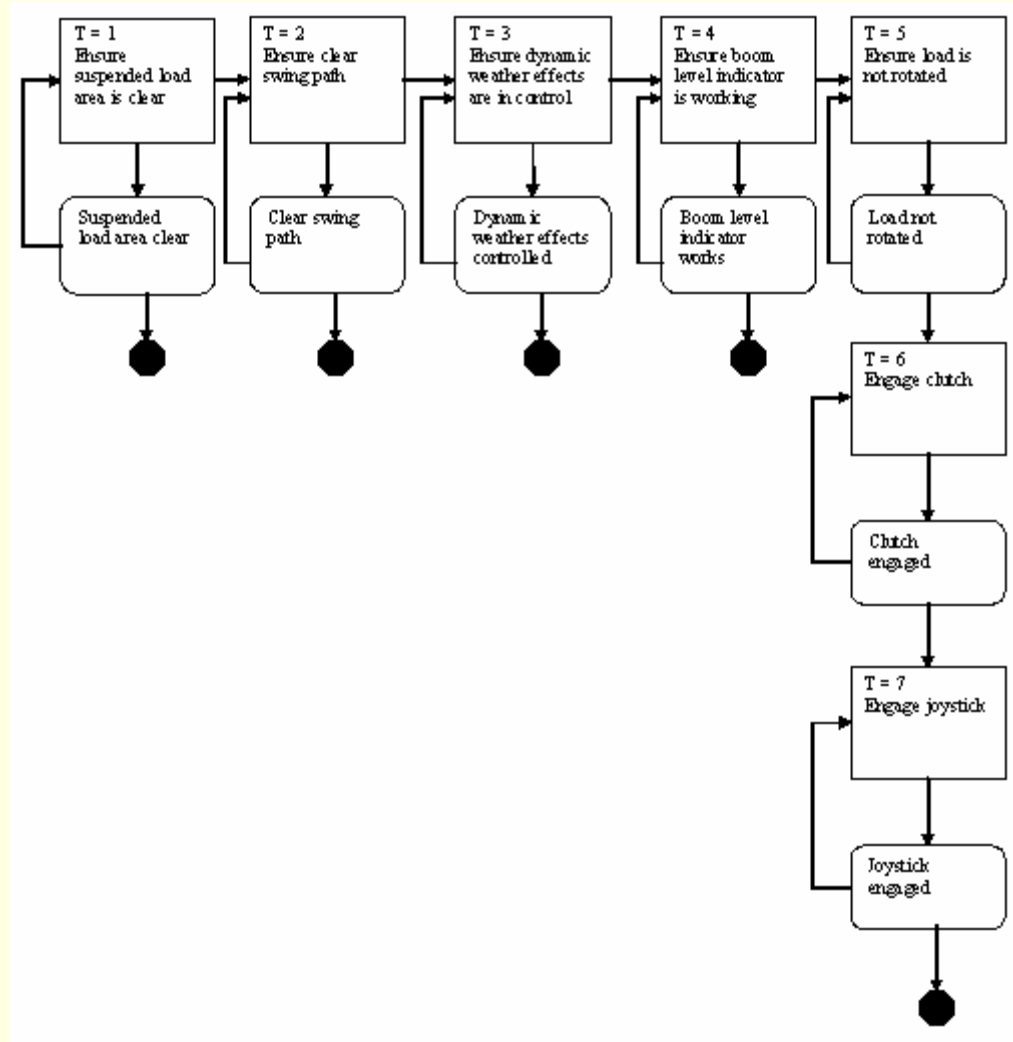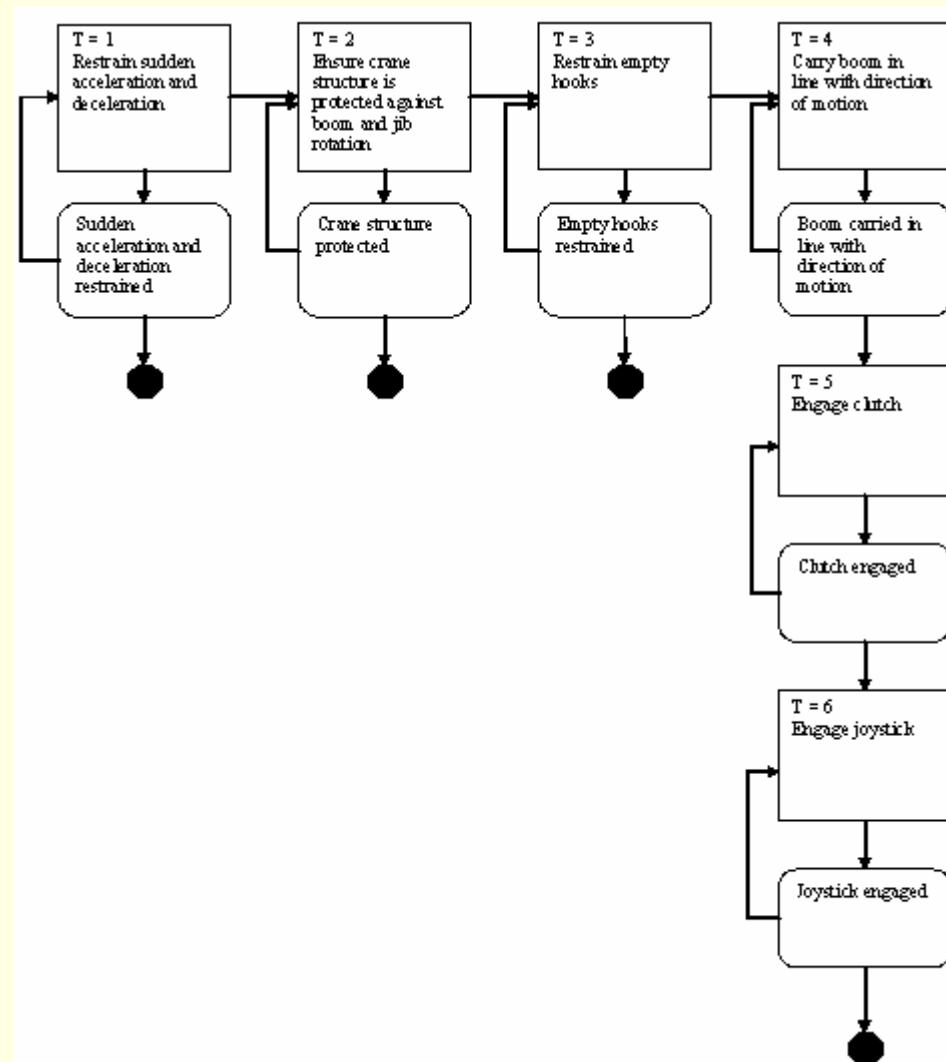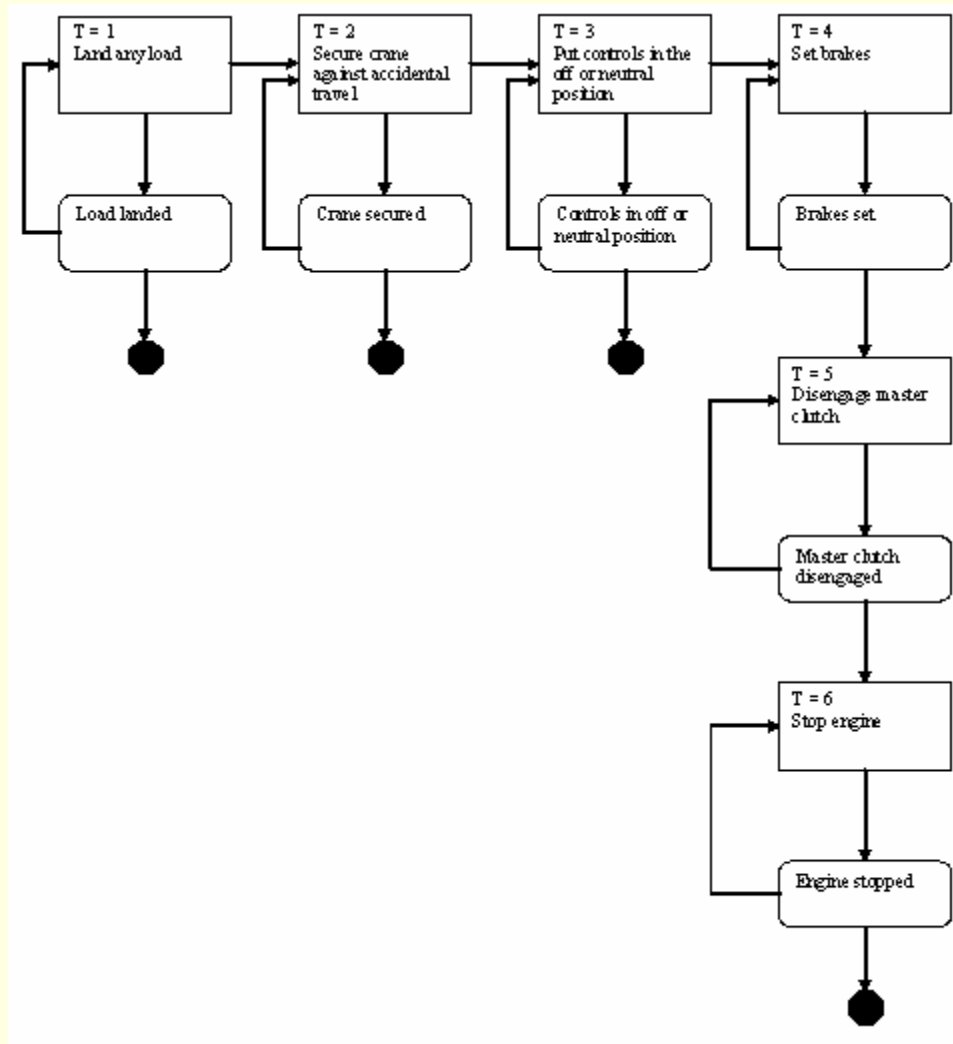| CRANE |
|---|
| Initiate Pre-Start Inspection |
| Handle and Attach the Load |
| Lift the Load |
| Maneuver the Load |
| End Lifting |
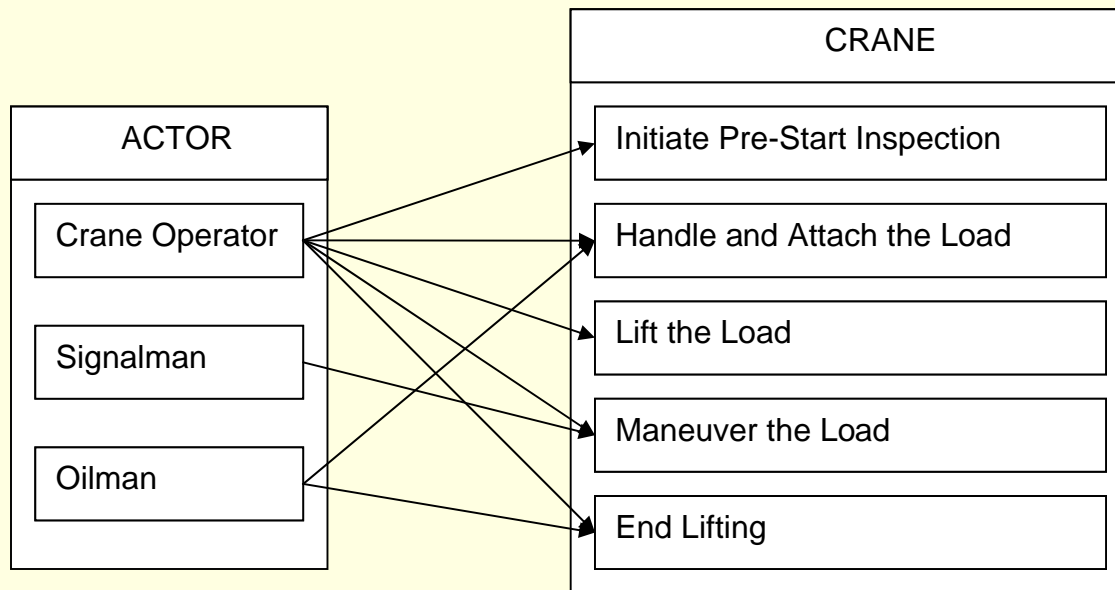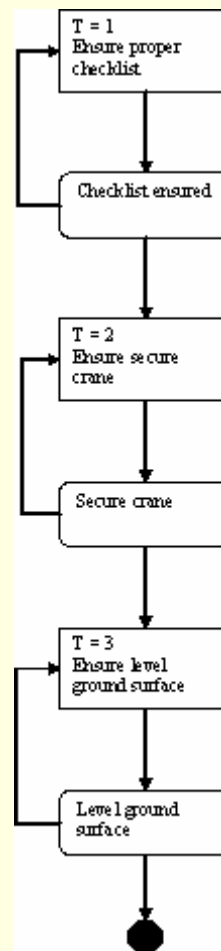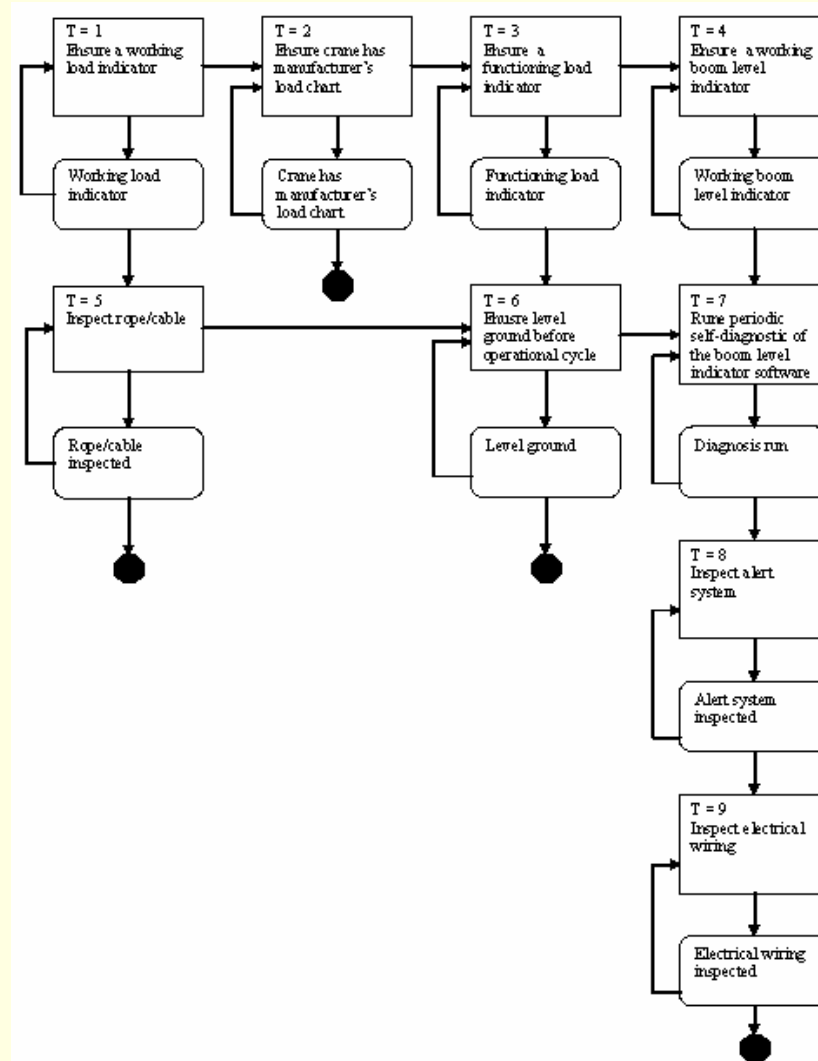
Phase 1

Phase 2

Phase 3

Phase 4

Phase 5

Off-Nominal Use Case Scenario

FMEA Analysis

- Cause and Effect Hazard Analysis

- Positive and Negative Use Cases

- Allocation of Negative to Positive Use Cases

Benefits

- Robustness in Design

- Pinpoint Design Flaws

- Error Proof

Requirements

Requirements based on Manufacturers Operational and Design Specifications

Operational Requirements used to create Main and Derived requirements

Requirements Verification Matrix used to verify design meets requirements specifications

Requirements Constraint and Analysis analyzes extent and implementation of requirements

Query Modeling and Validation

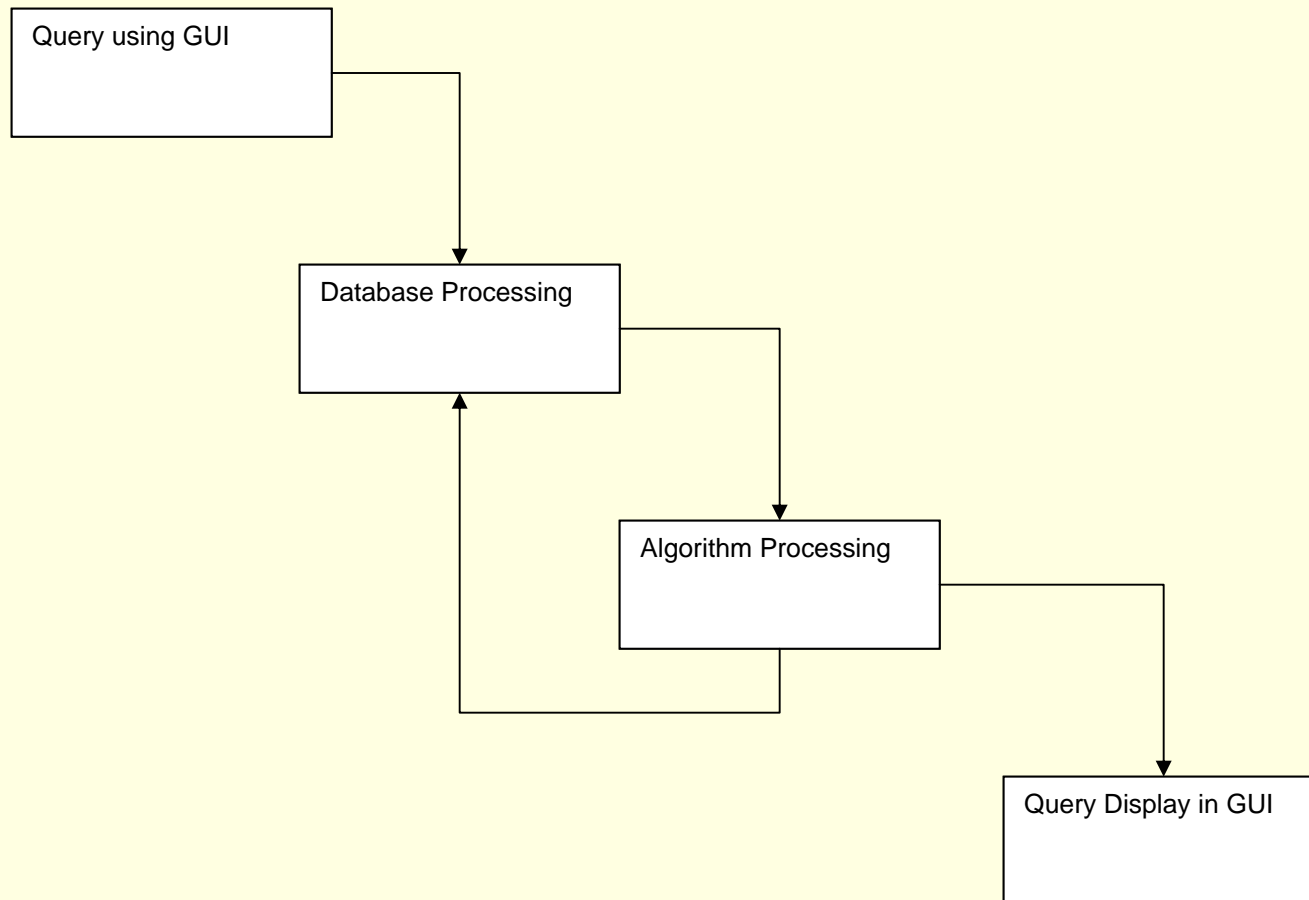UQLAT – UML Query and Link Analysis Tool

- Queries and dynamically links block elements of UML diagram

- Currently limited to Activity diagrams

Data Structure

- Block Element data structure as an element into processing algorithm

- Block ID	- Input
- Name	- Output
- Level	- NOI
- Phase	- NOO
- Time Element	- Recursive
- Action/State	- Pointer

Query Event Sequence

Query using GUI

Database Processing

Algorithm Processing

Query Display in GUI

Query Types

Query any one element within one phase

Query one element independently across many phases simultaneously

Query all the inputs from any one element within one phase

Query all the outputs from any one element within one phase

Query the link between any one element and other elements within one phase

Query the level of any element within any phase

Query Initiation Form

UQTAL Query Initiation Form   @ IDS - 2006

Program ID: HC 2671 - UQTAL QIF   Hydraulic Crane UML   **User ID:** DMathew

Query Mode: AC 1 - Activity Diagram   **Status:** UNCLAS   **Date:** 12-04-06   **Type:** ORDAT 2

Search Name Box: xxxxxxxxxxxxx   Input:

Level: Output:

Phase: NOI:

Time Element: NOO:

Action/State: Recursive:

                                                      Pointer: xxxxxxxxxxxx

PREVIEW   QUERY ?   SAVE

Query Results Form

UQTAL Query Results Form   @ *IDS - 2006*

Program ID: HC 2671 - UQTAL QIF   Hydraulic Crane UML   **User ID:** DMathew

Query Mode: AC 1 - Activity Diagram   **Status:** UNCLAS   **Date**: 12-04-06   **Type:** ORDAT 2

Input Parameters:

Primary Key — Block ID

Secondary Key — Phase 2

Output:

Total Elements:	18
Action Elements	9
State Elements	9

DIAGRAM LINK

QUERY ?

Block ID:

Action - BLB-ACD-01 BLB-ACD-02 BLB-ACD-03 BLB-ACD-04 BLB-ACD-05 BLB-ACD-06 BLB-ACD-07 BLB-ACD-08 BLB-ACD-09

State: BLB-ACD-10 BLB-ACD-11 BLB-ACD-12 BLB-ACD-13 BLB-ACD-14 BLB-ACD-15 BLB-ACD-16 BLB-ACD-17 BLB-ACD-18