



Quantum Applications

Transportation and Manufacturing

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Strategic vs Operational


<i>Integration</i>	Manual I/O	Tight Integration
<i>Requirements</i>	Easy to make assumptions	Hard to define all exceptions
<i>Interaction</i>	Scenarios / What-if	Manual Editing / Schedule Repair
<i>Solution</i>	Optimality	Feasibility
<i>User</i>	Business Expert	Operations
<i>Performance</i>	> Hours	< Seconds
	<i>Strategic Planning</i>	<i>Operational Scheduling</i>

Opportunity for Quantum

Airline Operations



Key Challenges in Travel and Transportation

- 
- Irregular Operations (IROPS)
 - Low customer satisfaction
 - Variable fuel prices
 - Increasing volume of traffic
 - Complex regulations

Challenges: Irregular Operations (IROPS)



Controllable causes

- Plane changes
- Maintenance delays
- Passenger misconnects
- Flight ops delays
- Airport ops delays
- Onboard delays



Uncontrollable causes

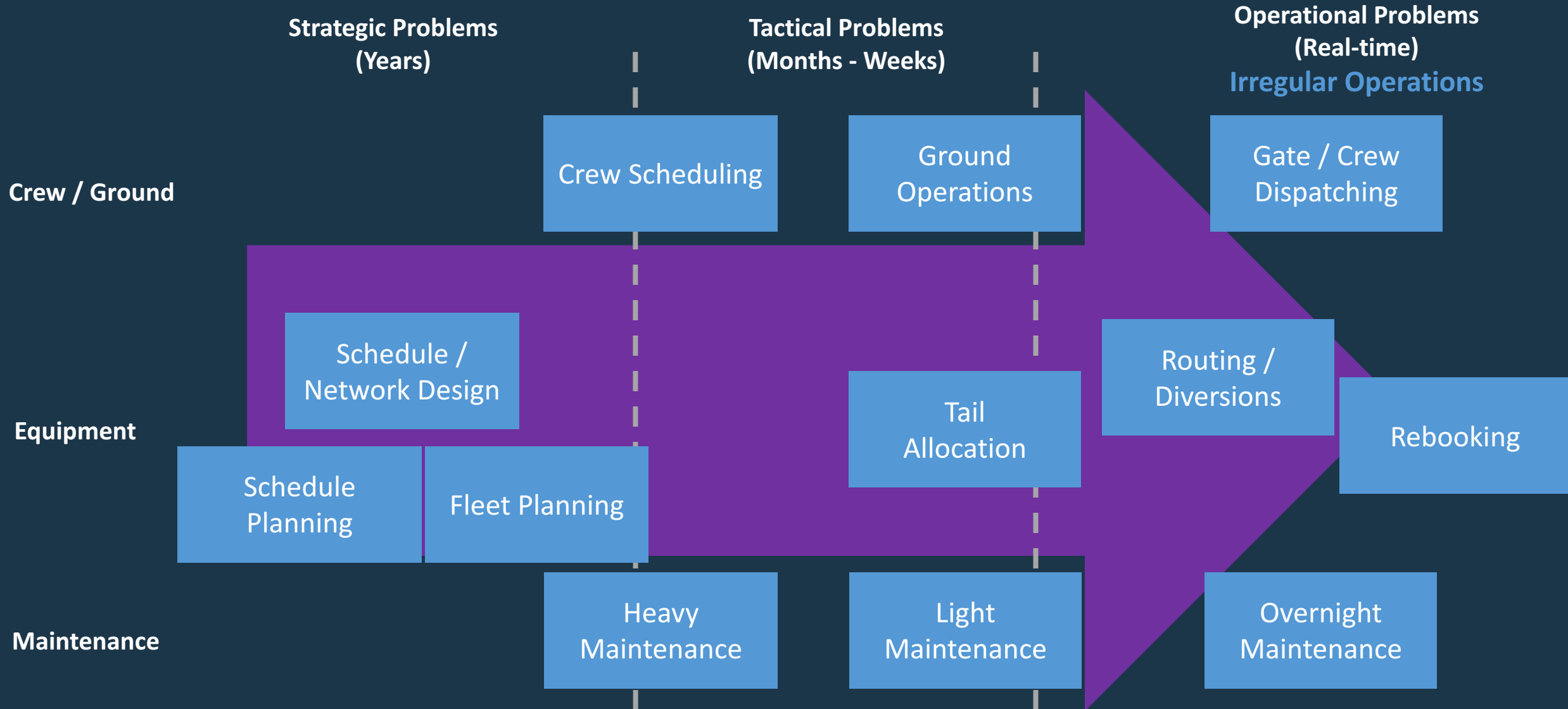
- Weather
- ATC
- Security
- Medical

**Recoverability
Opportunities**
~\$15-\$22 billion
USD / Year

- Estimated cost of airline disruptions: 2-3% of revenue
- Total industry revenue: \$736B in 2016
- Disruption cost range: \$15B-\$22B

Source: IATA

Airline Operations



Light Maintenance and Tail Allocation



Operational Inputs:

- **Landing Cycles, Flight Time/Miles, Routing**
- List of A Checks
- Hanger and bay availability and capacity
- Locations where a check can be performed
- Skills requirements and availability
- Manpower and Parts availability

Business Decisions:

- Where and when to perform maintenance
- **Updated Maintenance Requirements**



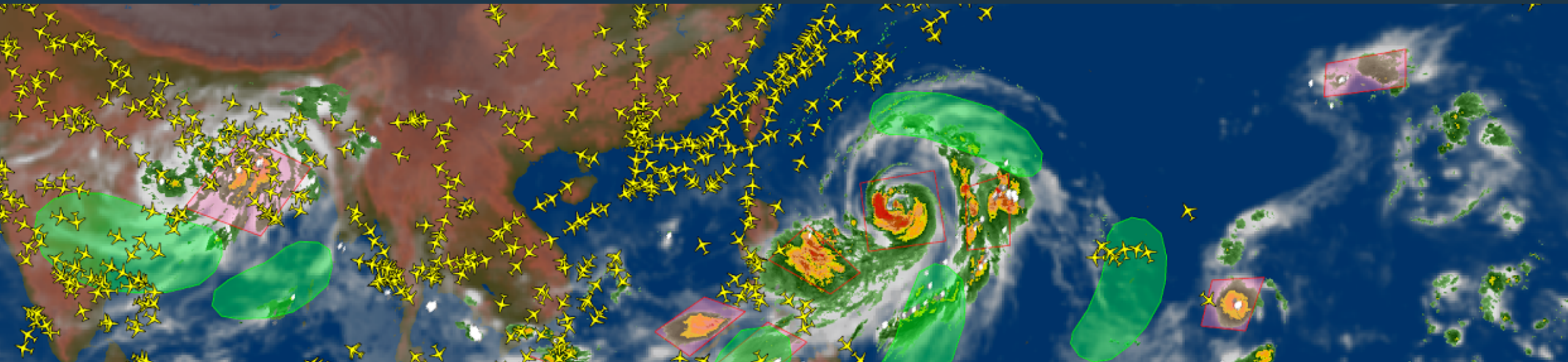
Operational Inputs

- **Maintenance Requirements**
- Segment Schedule
- Connection requirements
- Ground times per flight/pair of flights, airport

Business Decisions:

- **Updating Routing**

Diversion Management



Weather Impact on Airport

- Reduction in landing capacity

Business Decisions

- Divert some of the incoming flights
- Delay some of the incoming flights
- Hold some of the incoming flights

Operational Inputs

- Expected reduction in take-off and landing capacity
- Scheduled take-offs and landings
- Remaining flight times and fuel
- Alternative airports
- Hold pattern options

Gate Assignments

24 Hours Ahead Assignment Gate-Flight Assignments

Operational Inputs

- Flight schedule
- Gate availability
- Gate-Equipment Capabilities
- Proximity constraints
- Gate-Flight preferences

Irregular Operations (IRROPS) Business Decisions:

- Updated Gate assignment

Considerations:

- Minimize idling time on ground
- Number of gate changes
- Gate changes < 1 hour
- Proximity of new and old gates

Operational Crew Pairing and Scheduling



Flight



One day



Pairing



Monthly

Scheduled Flights

Equipment

One day schedule

Requirements

- Single Crew
- Equipment-Crew requirements
- Connections
- Rest at the end

Pairing schedule

Requirements

- Start / End at crew home base
- Pair up one-day schedules
- Max layover
- Min rest

Monthly schedule

Requirements

- Monthly limits
- Crew preferences
- Vacation
- Seniority



Irregular Operations

Other Transportation Problems

- **Logistics**

- Routing

- **Rail**

- Scheduling
- Routing
- Configuration

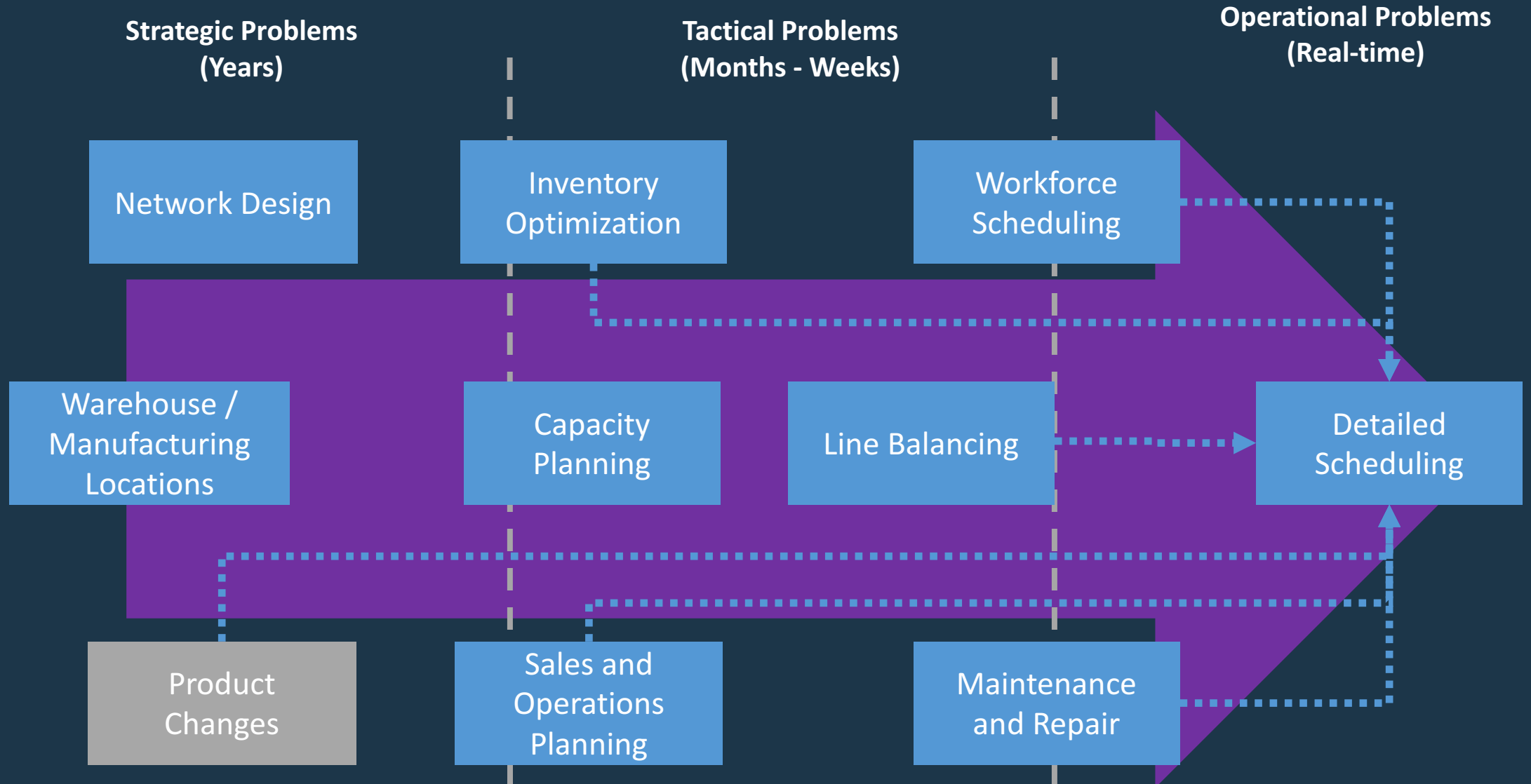
- **Ocean Freight**

- Container Repositioning

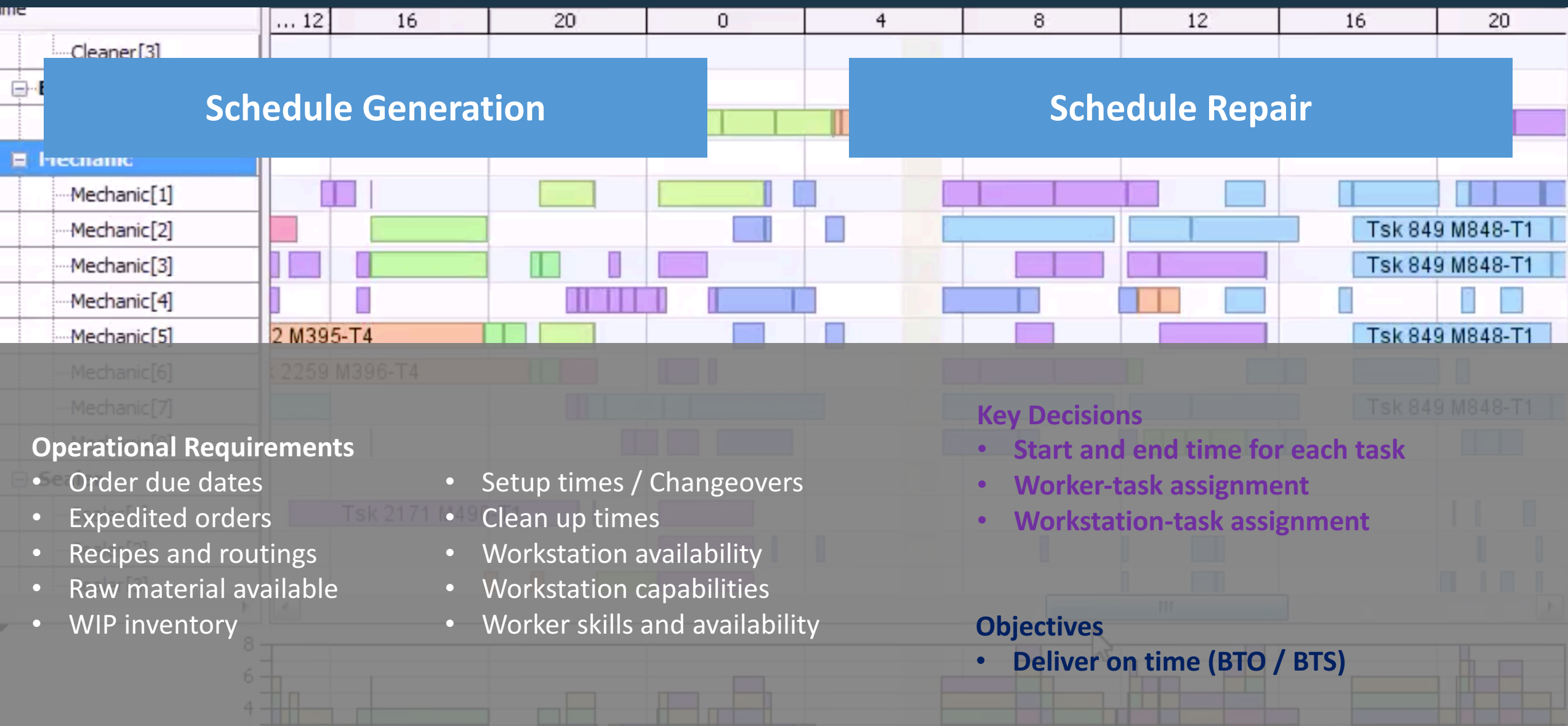
Manufacturing



Manufacturing (Discrete and Process)



Detailed Scheduling



Key Challenges in Scheduling

▪ Detailed Capacity Considerations

- Hard to consider major tradeoffs: Shifts, Equipment, Certifications, Orders and Customers

▪ Reliance on schedulers

- Decisions based on “experience” and “tradition”
- Hard to create and hard to repair schedules

▪ Complex dependencies

- Resource routings / Setup times / Cleaning times
- WIP Synchronization

▪ Dynamic Operations

- New orders / Inventory targets / Unplanned maintenance / quality assurance



Scheduling Across Manufacturing Industries

- **Automotive**

- Car sequencing through stations

- **Electronics**

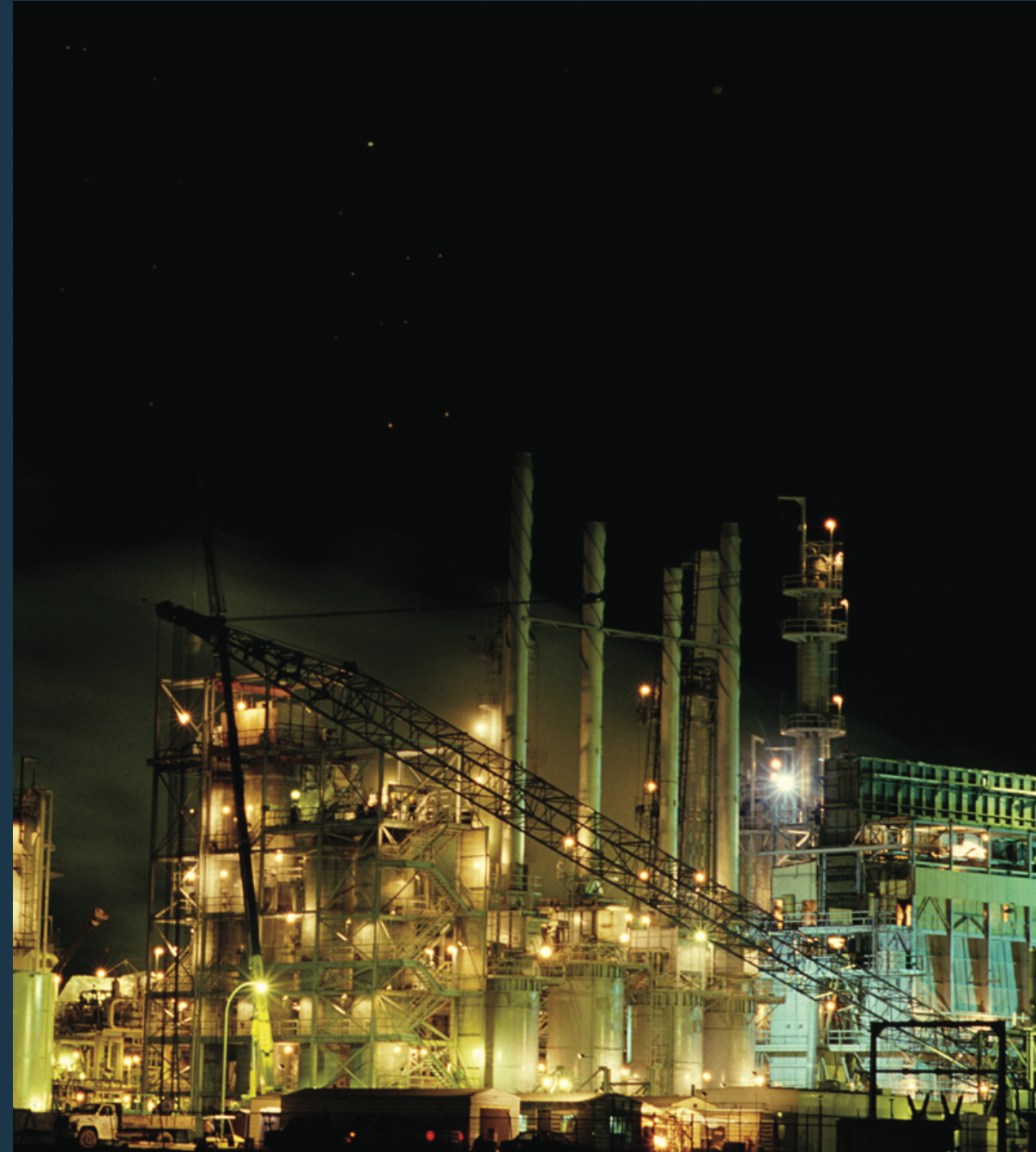
- Scheduling of batches through stations

- **Aerospace**

- Large scale assembly

- **Consumer Products**

- Size and timings for batch operations



Thank you!

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