Tracking Information for Sustainable Transportation Performance

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Set-Up

- Motivation: European Project
- Container Tracking
- Combined Mode Decision Problem
- Value of Information
- Conclusions & Future Research

European project “Integrity”

- Container transport China - Europe
- Motivated by enhanced information requirements security and logistics
- Development supply chain visibility system (green lanes)

Visibility The extent to which decision makers have quality information at their disposal

INTEGRITY

SEVENTH FRAMEWORK PROGRAMME

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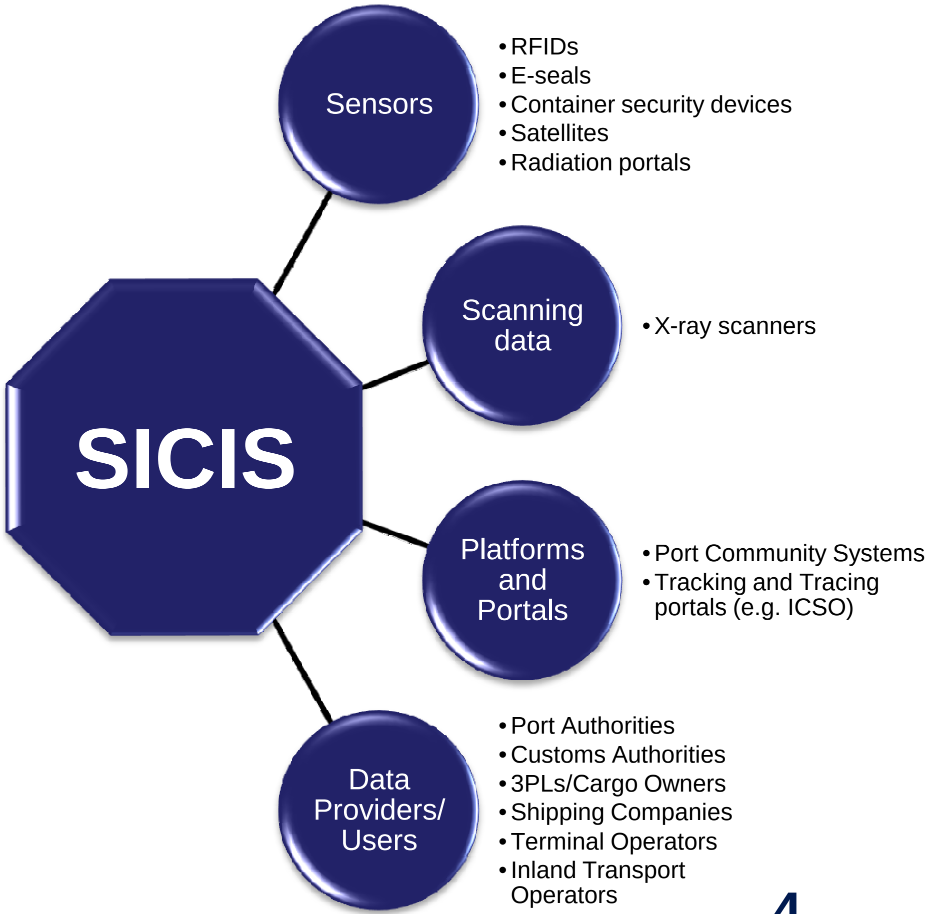
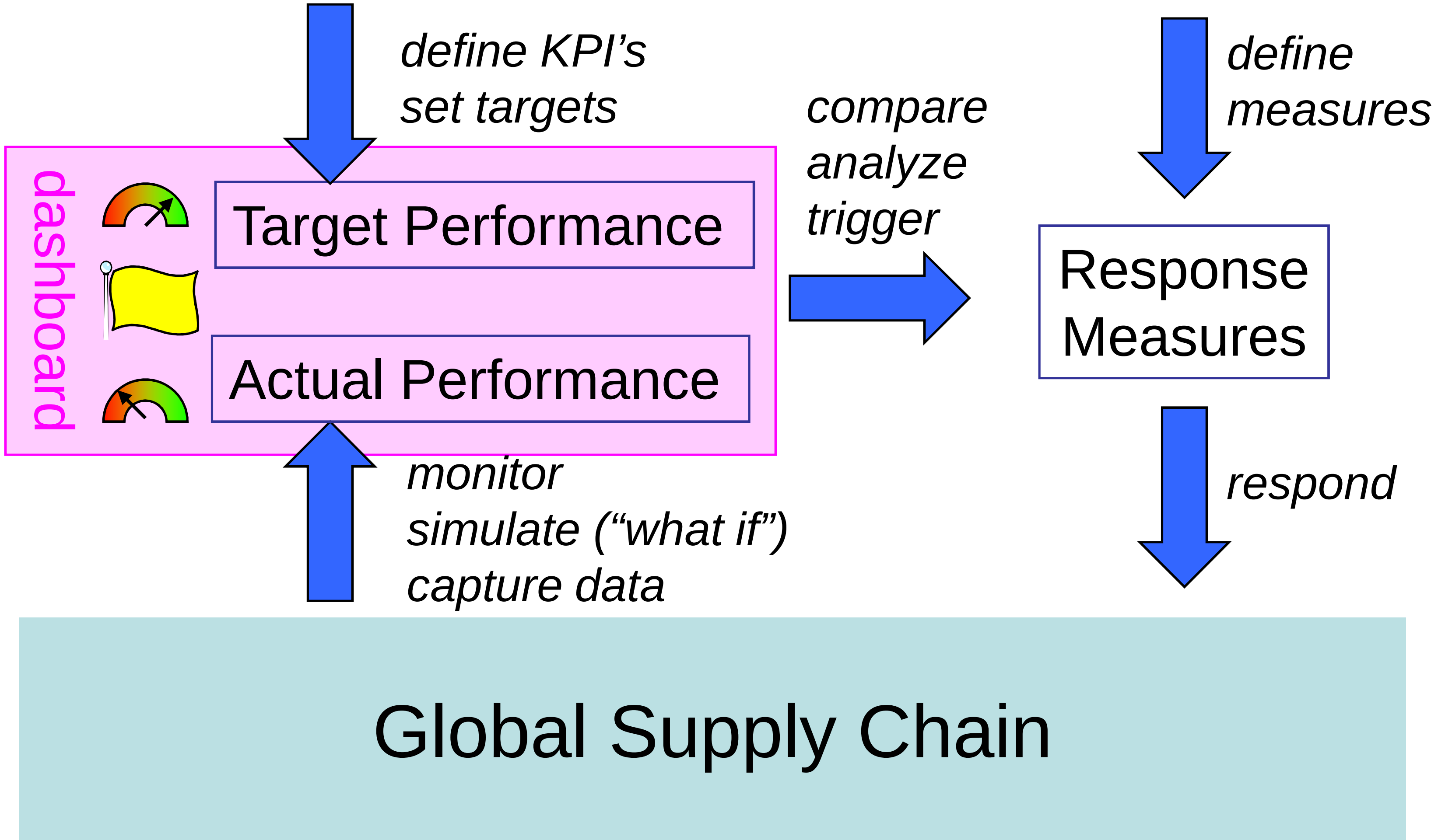
Inter-Organizational System

Shared Intermodal Container Information System



- Implementation of <u>one</u> visibility system
- Variety of stakeholders
- Variety of objectives
- Variety of requirements
- “Collateral Benefits”

Monitor and Control



(Corbett and Klassen, 2006; Lee and Whang, 2005)

Container Tracking Feature

Multiple data sources

- Container tag (GPS)
- Vessel tracking system (AIS)
- Vehicle board computers
- RFID readers at the terminal

Ports of Felixtowe: visible vessels and example for status of a selected ship:

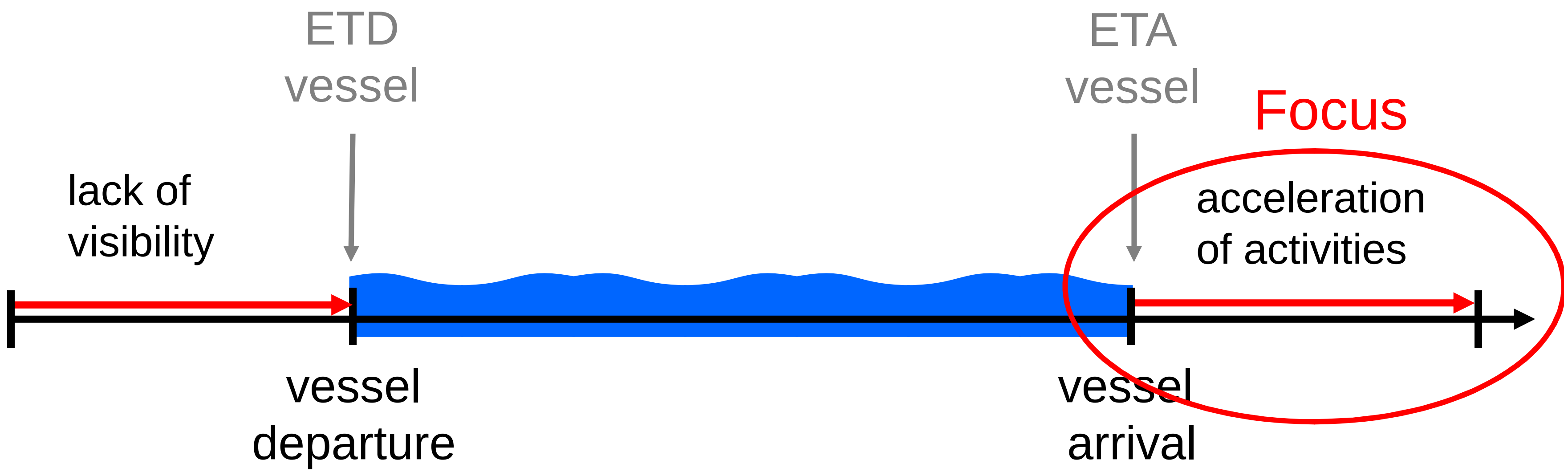
Use of quality tracking data

- Monitor and control of container position
- Forecasts of events (arrival times)

Research Directions

- Statistical analysis of tracking data for container arrival (release times) prognostics
- Drayage problems
- Use of tracking information for allocation reefer container logistics (shelf life perishables)
- Use of tracking information for support land transport mode choice

Global Supply Chain



'Decoupling points' departure and arrival deep sea vessel

- Departure and arrival times are uncertain (days)
- Present-day visibility requirements export low
- Acceleration of supply chain activities import upon arrival

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Control Measures

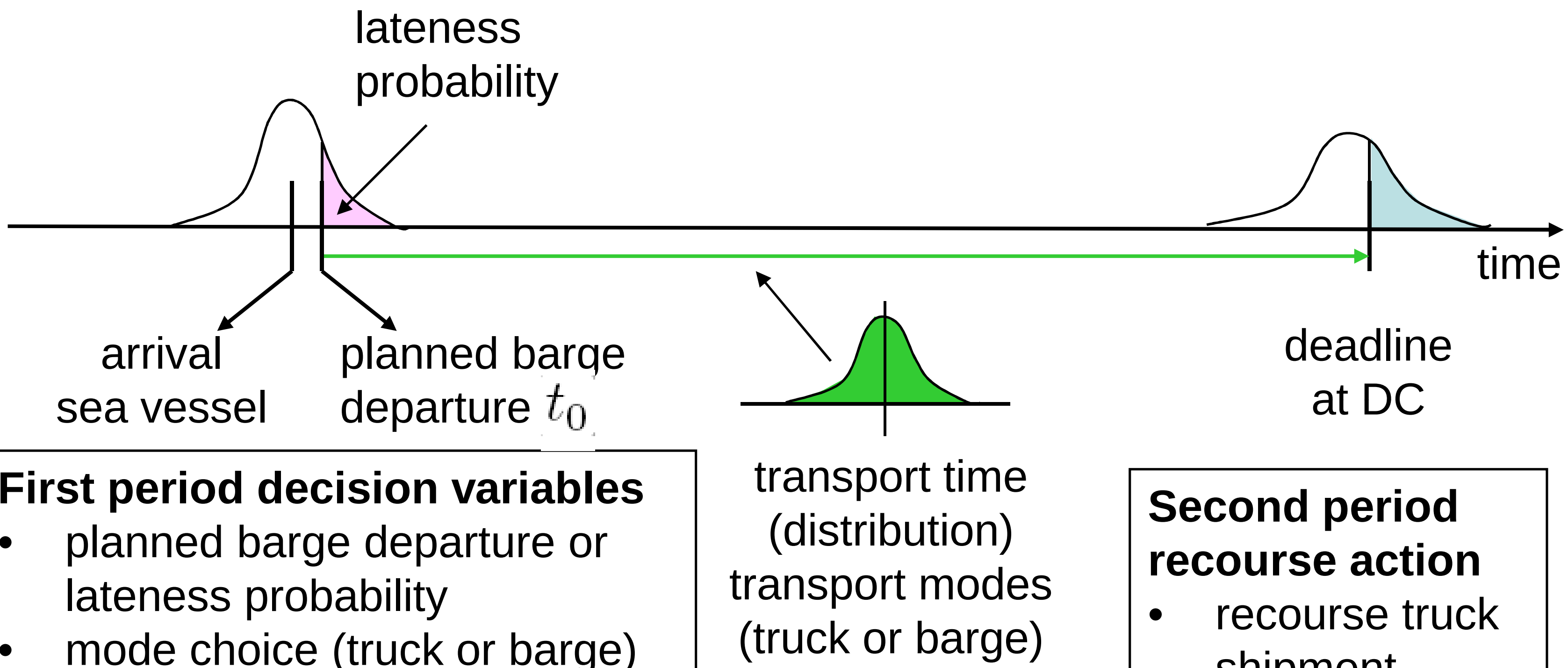
- Container arrival destination port
- Transport mode inland (barge or truck)
- Departure barge less flexible
- Co-modality: recourse shipment of late containers by truck
- Decision variables:

  fraction of containers planned by barge γ

  probability container not on time for barge

$$\alpha = 1 - F(t_0)$$

Decision Model



First period decision variables
- planned barge departure or lateness probability
- mode choice (truck or barge)

Second period recourse action
- recourse truck shipment

Stochastic parameters
- container release time
- transport times

Information Scenarios

1. **No information**

   All containers are shipped by recourse truck.

2. **Distributions container arrivals and transport times**

   Fraction is planned to be shipped by barge, late arrivals are shipped by recourse truck. Remainder is shipped by planned truck.

3. **Container arrivals known beforehand**

   Fraction is planned to be shipped by barge, and remainder is shipped by planned truck.

4. **Complete information**

   Same, only transport times taken into account when selecting containers for barge shipment.

Performance Measures

distance = 170 km	**barge**	**truck**
costs (euro)	70	200
time (hours)	12	4
CO2 emissions (kg/ton)	6	23

Sources: personal communication LSP;
CO2 Emissions from Freight Transport in the UK (2007)

- transport costs
- emissions

} normalized $\sigma = \frac{c_{\text{rctruck}} - c}{c_{\text{rctruck}} - c_{\text{barge}}}$

- fraction containers shipped as planned (security) s

- fraction containers on time at DC ρ

Scenario Performance

$$\rho_2(\alpha,\gamma) = \gamma \int_{t_0}^{T} G_{\text{rctruck}}(T-t) f(t)\, dt + \gamma(1-\alpha) G_{\text{barge}}(T-t_0) + (1-\gamma)\int_0^T G_{\text{truck}}(T-t) f(t)\, dt.$$

$$\rho_3(\alpha,\gamma) = \gamma(1-\alpha) G_{\text{barge}}(T-t_0) + (1-\gamma)\int_0^{t_0} G_{\text{truck}}(T-t) f(t)\, dt + \int_{t_0}^{T} G_{\text{truck}}(T-t) f(t)\, dt.$$

(first order stochastic dominance)

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Pareto Frontiers Comparison

$\mathcal{E} \preceq \mathcal{F}$: for each $u \in \mathcal{E}$ there exists $v \in \mathcal{F}$ such that $u \leq v$.

Need to show:

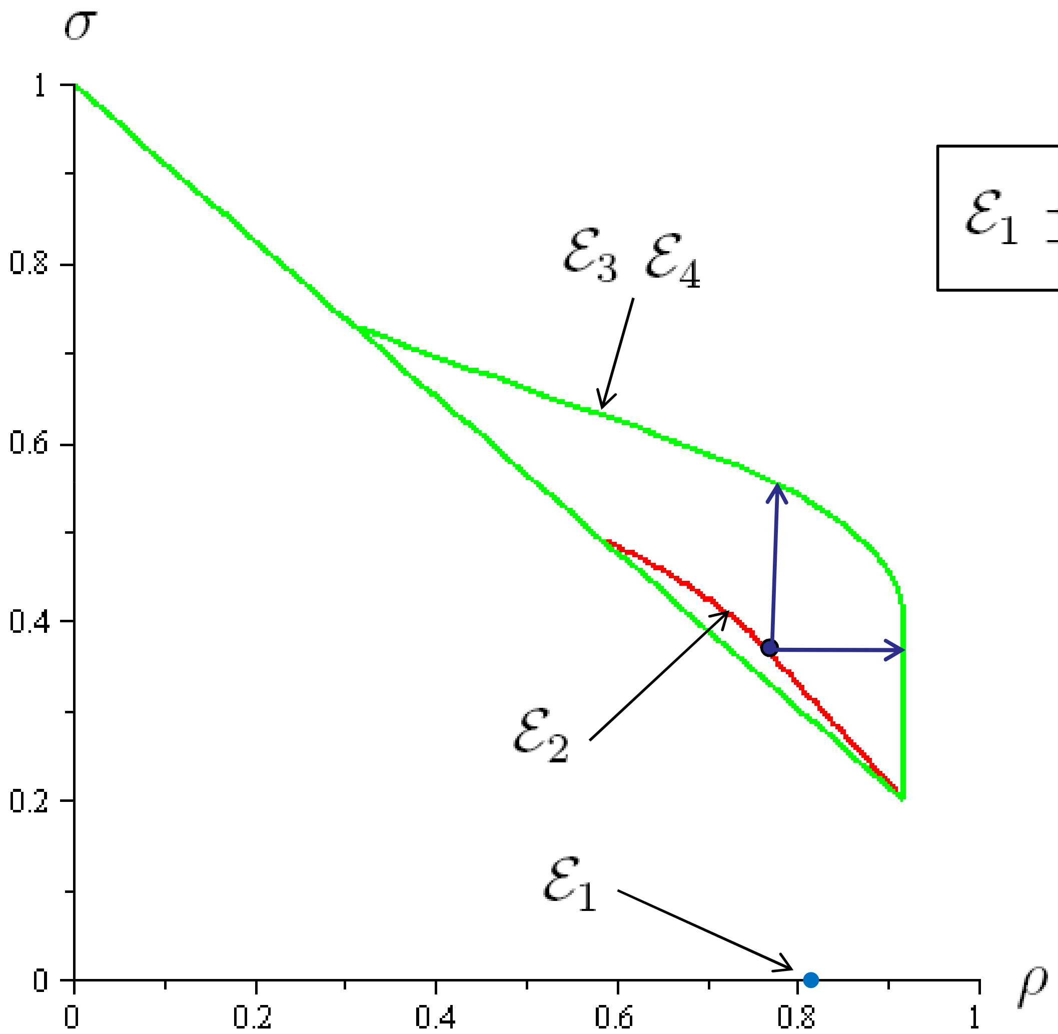
$$(\sigma_k(\alpha,\gamma), \rho_k(\alpha,\gamma), s_k(\alpha,\gamma)) \leq$$

$$(\sigma_{k+1}(\alpha',\gamma'), \rho_{k+1}(\alpha',\gamma'), s_{k+1}(\alpha',\gamma'))$$

“value of information”: scalarization versus pareto frontiers

(Ehrgott and Gandibleux, 2002)

Pareto Frontiers



$$\mathcal{E}_1 \preceq \mathcal{E}_2 \preceq \mathcal{E}_3 \preceq \mathcal{E}_4$$

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Conclusions

1. Potential use of tracking data in global supply chains motivates study of quantitative decision models to capture value of information
2. Progressive information scenarios result in added value of information, appearing as “shifts” of Pareto frontiers in positive direction

Future Research

Extensions Decision Problem

- Multiple deadlines and destinations, multiple barges and/or trains (intermodal network service design)
- Continuous scale of progressive information scenarios
- Validation and incorporation of real tracking data from Integrity project