Logistics planning: Tasks, procedures and rules

Prof. h. c. Dr.-Ing. Dr. h. c. (UCLV) Elke Glistau
Institute of Logistics and Material Handling Systems, Otto von Guericke University Magdeburg, Germany, elke.glistau@ovgu.de

Prof. Dr.-Ing. Sebastian Trojahn
Anhalt University of Applied Sciences Bernburg, Germany;
Institute of Logistics and Material Handling Systems, Otto von Guericke University Magdeburg, Germany

Prof. Dr.-Ing. Dr. h.c. Prof. h.c. Norge Isaias Coello Machado
Department of Mechanical Engineering, Universidad Central "Marta Abreu" de Las Villas, Cuba

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Abstract
Logistics planning is a main discipline of the science of logistics. New trends and developments change requirements, approaches and solutions of logistics planning. The scientific problem is to check, identify, generate and document new and updated knowledge in this field. In this respect, the paper focuses on logistics planning tasks, on procedures, on trends and their effects, and on new or adapted rules of logistics planning.

1. Introduction
The identified research gap is in the knowledge of logistics planning. To this end, the research addresses and answers the following research questions:

1. Which logistics planning tasks can be distinguished?
2. Which approaches exist in logistics planning?
3. Which new trends and developments exist? How do they change and influence logistics planning?
4. What new knowledge on logistics planning can be derived from (3.)?
5. Which research questions regarding logistics planning need to be answered?

2. Methodology
The research is based on a comprehensive literature review combined with the authors' many years of expertise in the field of logistics planning and the evaluation of current research projects and trends. Well-known methods are applied. These are the morphological box, process description methods for the procedures of logistics planning, profiles for the trends and selected evaluation methods.

3. Results and Discussion
Overall, the following research results were obtained:

1. Morphological box for the characterization of logistics planning tasks.
2. Collection of established procedures of logistics planning.
3. Profiles of trends and definition of their impact on logistics planning.
4. Documented knowledge on new planning rules.
5. New research questions on logistics planning.

These research findings are excerpted and briefly explained below.

3.1. Result 1: Morphological box for characterization of logistics planning tasks
Logistics is a large scientific field and includes many tasks and new tasks are constantly added. This raises the question of a suitable systematization. A complete and consistent classification of all logistics planning tasks according to their content and subject matter is hardly possible and not known.

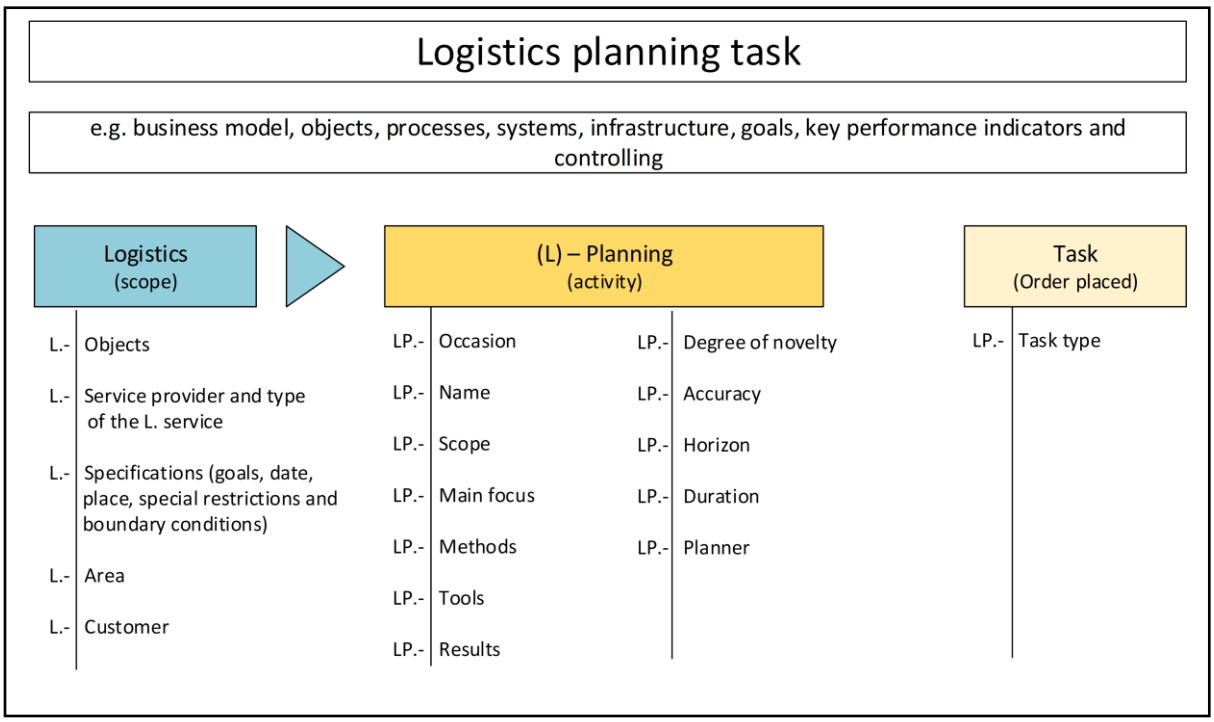

Figure 1: Logistics planning task

Existing scientific works work with exemplary task catalogues, e.g. Gudehus [1], with structuring models e. g. Pfohl [2] and Ziems [3] or limit the considered area first e.g. tasks of logistics planning in the automotive industry along the product development process e.g. Schneider [4], Schedlbauer [5]. In this paper (cf. Figure 1) the term "Logistics planning task" is subdivided into its three subwords: “Logistics” stands for the application area, “Planning” for the activity to be performed, and “Task” for the difficulty of the problem to be solved. Table 1 contains an attribute listing for the basic characterization of logistics planning tasks. Multiple entries in one row are also possible.

Table 1: Attribute Listing for logistics planning tasks (open list)

Attribute	**Possible characteristics (examples)**
Logistics objects (Type of goods	General logistics goods Persons as log. objects Information as log. objects General cargo; bulk cargo Dangerous Goods Art and museum goods Refrigerated cargo Heavy cargo Special cargo Express cargo
Logistics service provider and logistics service	1PL, 2PL, 3PL, 4PL, 5PL Type and scope of logistics activities
Specifications of the logistics provider	Goals Places and dates Requirements Restrictions Trends
Relevant Logistics part area (cf. [6], [7], [8])	Supply Chain Management Information logistics Corporate logistics (Industry, Trade, Service) Procurement logistics Production logistics Distribution logistics and sale Reverse Logistics & Disposal Logistics Warehouse logistics and buffer Traffic logistics Transport logistics Spare parts logistics and service Inbound logistics Intra logistics Outbound logistics City logistics Military logistics Hospital logistics *Space logistics*
Logistics customer	Customer characteristics
Planning occasion (Reference to the life cycle of a planning solution)	***Innovation*** Technological leaps Market change Product changes (logistic objects) New construction New design Modernization,

	Hazard protection/ plant safeguarding Rationalization Reconstruction, change of use
	Requirements (authorities) Organization Malfunction Expansion Insourcing/outsourcing Structural change (e.g. relocation) **Operation** Deconstruction Dismantling, demolition, redevelopment
Planning name (Designation of the planning task (concrete designation of the object of planning, logistical problem)	Network planning Site planning General development plan Structure plan Material flow planning Business process planning Facility planning Layout planning Sequence planning Route planning
Planning scope	Preparatory analyses Task definition (specifications) Concept (functional specification) Comparison and -selection Testing Feasibility study Implementation planning Accompanying realization Start-up planning Evaluation Remediation Utilization
Planning focal points (planning area)	***Business model*** Logistics object (goods, packaging, logistics equipment, loading unit) Logistics processes (material, information, *financial and energy flows;* technologies) Logistics system (*CPS*, MFS, IFS, FFS, EFS; network, factory to individual workstation) Logistics infrastructure (Technical, social, *green, blue*)
Planning methods and tools (defaults)	Key figure project planning Model project planning Modular project planning Catalogue project planning Planning software (algorithms (also ***AI, Big Data Analytics***, APS), MIS, BI, CAD, databases, project management, simulation, VR, AR), ***Digital twin***
Planning result (specifi-cations)	Documentation (according to planning scope) Calculation results key figures 2D plan/drawing 3D model Functional model Animation Simulation model VR, AR Video *Digital twin*
Planning degree of novelty	Base technology Improvement based on actual Benchmarking (best practice) Completely new target
Planning-accuracy	Rough (study) Medium (standard plan) Fine (Detailed plan, execution)
Planning horizon	*Futurology (science)* Normative, value-based Long-term, strategic Medium-term, tactical Short-term, operational
Planning duration (defaults)	long medium (standard) short Real time
Planner (specifi-cations)	mainly internal internal and external mainly external
Task type (cf. [9], [10])	Routine planning task analytical problem synthetic problem dialectic problem

Legend:

- Highlighted in *italics* = what is new.
- **Bold highlighted** = what is particularly important.

3.2. Result 2: Collection of established logistics planning procedures

There are various published approaches to logistics planning or approaches that are also relevant and useful for logistics planning.
Some important examples, recorded in an open list without claim to completeness, are:

- **Material flow planning** (7-step planning system according to [11].
- **Transportation planning** (4-step approach according to [12])
- **Site planning** (according to [13])
- **Product development** (design)
  - Problem solving cycle (according to Ehrenspiel [14]
  - VDI guideline 2221 (see [15])
- **Software planning** (computer science)
  - V-model (cf. [16])
  - Waterfall model [16]
  - Spiral model [16]
  - Scrum [16]
  - Kanban [16]
- **Packaging planning** 5 steps [17]
- **Investment planning**
  - 5 phases according to Olfert [18]
  - structured approach Ziems [19]
- **Factory planning**
  - 5 phases (based on [20]
  - Planning levels of factory planning (based on [21])
  - Procedure according to VDI 5200, sheet 1 [22]
- **Production planning** (production program planning, procurement planning, sales planning, scheduling and dispatching of operating resources, labour, material, tools and auxiliary materials; planning of lot sizes, throughput and capacity scheduling, sequence planning, detailed scheduling; dispatching and disturbance control)
  - task-oriented [23], [24], [25].
- **Project management** (project structuring, sequence planning, scheduling, resource planning, cost planning).
  - 4-phases (based on [26], [27], [28]
  - according to DIN 69901 [29], [30]
  - according to DIN 69909 [31]
- **Supply chain management** (cf. e.g. [32]) integrative and hierarchical approaches e.g. SC configuration, SC planning (sales planning, network planning, procurement planning, production planning, distribution planning, disposal planning, SC execution (scheduling and disruption management)
- **Logistics 4.0** (cf. [33], [34], [35]) Planning of logistics solutions according to the Smart Logistics Zone (business model, object, process, system and infrastructure)
- **Sustainability planning** (cf. [36], [37]) e.g., planning and optimization of compliance with laws and regulations, planning of waivers, planning of efficiency improvement, planning of new solutions, planning of compensatory measures.

Further examples are e.g. target planning, planning of analyses including forecasts, dimensioning (number planning), structure planning, warehouse planning, planning of digital factories, planning of order picking, financial planning and cost calculations, area planning, planning of function testing, batch size planning, planning of machine set-up and overall layout, scheduling, sequence planning, route planning, planning of collective runs, round trips and distribution runs as well as organizational planning**.**
Without reference to a specific planning task and its specifics, the logistics planning process can be generally described, for example, as follows:

- **Planning impulse**
- **Problem definition**
- **Specifying the task**
- **Target planning**
- **Planning and execution of analyses** (Determine and prepare planning data, elicit solution options)
- **Planning of the target solution**, if necessary in variants
  - Planning of business models, logistics objects, processes, structures, systems, infrastructures and organizations
  - Establishment and exclusion of alternatives
  - Evaluation and decision-making regarding the best alternative
- **Detailed planning**
- **Implementation planning**
- **Planning implementation support**
- **Planning in operation**
- **Accompanying and final evaluation**

Due to the diversity and complexity, the formulation of a general, standardized procedure for every logistics planning task is not feasible. In this sense, the described procedure should only provide a basic orientation. Details and the individual approach as well as the methods and tools used have to be adapted specifically to each individual case.

3.3. Result 3: Fact Sheets for Trends and Impacts on Logistics Planning

To answer the research question: What new trends and developments exist? these were first researched in the literature. (cf. among others [38], [6]).
In this paper, the so-called DHL trends are used for the sake of clarity. (cf. [38])
Then, the question was investigated: How do the trends and developments change and influence

logistics planning? For the evaluation of the influence an evaluation scheme was established. Figure 2 shows the relevant evaluation aspects. The upper part of the picture (marked in orange) shows the components of the logistics solution. The left side of the picture (marked in yellow) illustrates important input variables of the planning. In the middle part (marked in grey), the actual planning is characterized on the basis of five formative aspects. The right part of the picture (marked in turquoise) is dedicated to the planning results and the evaluation.
Tables 2 and 3 show results and contain important current trends and their impact on logistics planning using the systematics of Fig. 2.
The symbols in tables 2 and 3 have the following meaning:
* = noticeable influence
X = great influence
X = determining influence

Note: The evaluation of the influence on logistics planning in tables 2 and 3 corresponds to the subjective opinion of the authors and their scientific environment. This evaluation is hereby put forward for broad scientific discussion.
After individual evaluation and ordering of the trends, the following patterns and thus groups become visible. They have been marked in color. In addition, the corresponding changes can be read off column by column.

The influences should be considered in order to generally meet the changed requirements and opportunities (effectiveness), but also to make planning efficient. This concerns the reduction of the planning effort, the improvement of the planning quality and the increase of the planning speed. From the tables 2 and 3 the influences on logistics planning can be read out and verbally summarized.

A few examples will be given:
(1) With regard to the logistics object, it can be seen that it is becoming more intelligent and autonomous. One example is smart containerization. Another important trend is Rethinking Packaging.
(2) Infrastructure is becoming more important for finding solutions. For example, the presence of 5 G networks is crucial for certain logistics solutions based on image processing or Big Data analytics.
(3) Energy aspects should increasingly be considered. For example, decentralized solutions such as cargo bike depots or autonomous conveyor technology also require a functioning energetic solution.
(4) The boundaries between material, informational, organizational and energetic solutions are becoming blurred and cannot be clearly assigned in some cases. Examples include cyber-physical systems where, for example, sensors serve multiple flows.
(5) There are some new target and evaluation categories for logistics that complement the classic parameters such as cost, time and

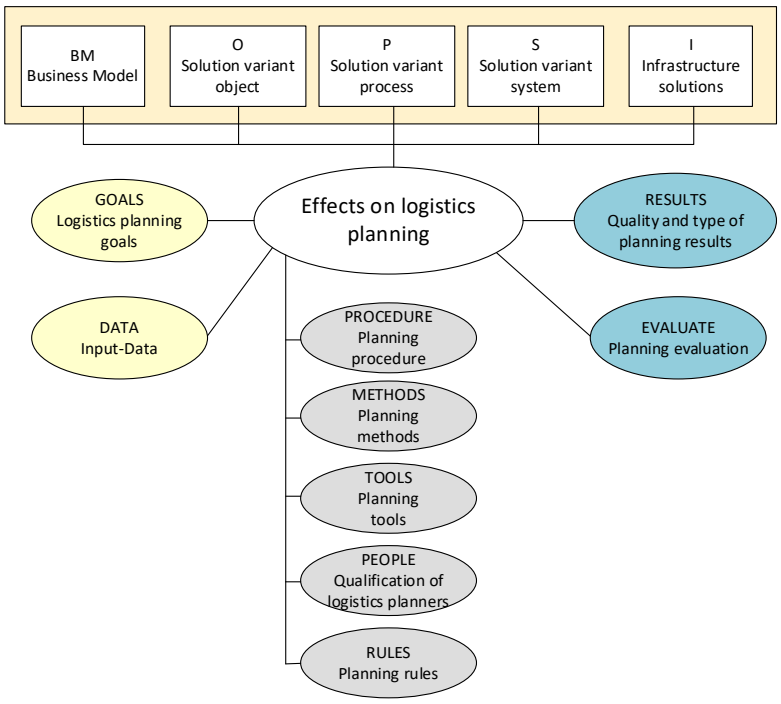

Figure 2: Relevant effects on logistics planning

Table 2: Influence of social & business trends according [38] on logistics planning

Social & Business Trends [38]	Influence on logistics planning (own work)													
	IN		SOLUTION					PLANNING					OUT	
Own work: clustering	GOALS	DATA	B-MODEL	OBJECT	PROCESS	SYSTEM	INFRA	PROCEDURE	METHODS	TOOLS	PEOPLE	RULES	RESULTS	EVALUATE
Supergrid Logistics			**X**											
Logistics Marketplaces			**X**											
Sharing Economy			**X**											
Servitization			**X**											
Silver Economy			**X**											
Space Logistics			**X**											
Multisourcing					**X**									
Omnichannel Logistics					**X**									
Mass Personalization	*	X	**X**	X	**X**	X						X		X
Fresh Chain			*		**X**	*								
Smart Containerization				**X**	X									
Rethinking Packaging	*			**X**		*								*
Sustainable Logistics	**X**	*	*	*	*	*	*	*	X	*	*	*		**X**
Next-Generations Security	**X**	X	*		*	X		X	X	X	X	X		**X**
Future of Work	*					*					**X**			*

Table 3: Influence of technology trends according [38] on logistics planning

Technology Trends [38]	Influence on logistics planning (own work)													
	IN		SOLUTION					PLANNING					OUT	
Own work: clustering	GOALS	DATA	B-MODEL	OBJECT	PROCESS	SYSTEM	INFRA	PROCEDURE	METHODS	TOOLS	PEOPLE	RULES	RESULTS	EVALUATE
Self-Driving Vehicles		X	*		X	**X**	X	X			*			
Unmanned Aerial Vehicles		X	X		X	**X**	X				X			
Robotics & Automation		X	*			**X**	X			*				X
Bionic Enhancement	X	*	X			**X**	*		X		X	X	X	X
3D Printing			*		**X**	**X**								
Artificial Intelligence		X	*			x		X	**X**	**X**	X			
Big Data Analytics		X	*					X	**X**	**X**	X			
Augmented & Virtual Reality			*					X	**X**	**X**	X		**X**	X
Internet of Things			*	*	X	**X**	X		X	X	X	X	X	X
Next-Generation Wireless						**X**	**X**							
Blockchain			*	*		**X**		X	X	*	X	X	X	
Cloud & APIs						*	*	X		**X**				
Digital Twins	*	X	*			X		X	*	**X**	*	*	**X**	X
Quantum computing										**X**				

quality. These are e.g. sustainability and safety, but also scalability and adaptability.

(6) The use of digital technologies is changing the planning process. This concern, for example, the use of techniques such as virtual reality (VR), augmented reality (AR), data storage in the cloud or distributed project work. Engineering takes place in the cloud, including simulations. At the same time, the requirements for the qualification of logistics planners are changing.

3.4. Result 4: Documented knowledge of planning rules

There are already rules for logistics planning processes in the literature. (e.g. [39], [40])
The updated knowledge includes, for example, current recommendations for logistics planning. (cf. Table 4). Table 4 contains some examples for the business model, for logistics objects and for logistics processes to illustrate changed rules.

Table 4: Examples of new recommendations for logistics planning (business model, logistics objects and logistics processes only)

Planning focus	**Explanation**
Business model	***Consider new business models Define the logistics portfolio e.g. driven by innovation and opportunities (expand, adapt or redefine business models).***
Logistics objects	Form purposeful units (e.g. procurement unit = production unit = transport unit = storage unit = packaging unit = shipping unit = trading unit) or ***plan a minimal effort order picking.***
Logistics objects	Classify logistics objects to simplify and reduce the planning effort.
Logistics objects	***Decide on the intelligence of objects*** *and test the use of intelligent objects (Identification, Localization, Data Collection, Data Processing, Data Storage, Communication skills, Making decisions).*
Logistics objects	***Pay attention to sustainability and security of logistics objects.*** Use, protect, secure and design sustainably according to requirements, processes and systems (part, product, packaging, loading unit, service).
Logistics processes	***Define a new ideal of the process:*** *effective, efficient, safe and sustainable.*
Logistics processes	**Plan material, information**, ***financial and energy flows equally.***
Logistics processes	**Test all four approaches to process planning if possible**: Known basic processes, Kaizen (improve as-is), Business Reengineering (new to-be) or Benchmarking (reuse best performance).
Logistics processes	***Question new solutions for processes*** *with regard to goals, trends, sustainability, value and waste, freedom from errors, automation, digitalization and networking, potentials, weaknesses, ergonomics, focus, Corporate culture and controlling.*
Logistics processes	**Define clear and consistent process goals, standards, rules, measurement points and metrics.**
Logistics processes	**Pay attention to disruptions and risks** in planning, "normal operation" is always also subject to disruptions and latent risks.
Logistics processes	**Tests process structures and sub-processes** (e.g. bundling, integration, parallelization, splitting, extending, shortening, eliminating, differentiating, swapping).
Logistics processes	**Define clear processes** (e.g. fetch, bring, control centres, decentralized control, stations) or ***allow decentralized degrees of freedom.***
Logistics processes	***Set up measurement points for tracking and tracing.***
Logistics processes	**Design main processes** (material) and **secondary and integrating processes** (e.g. waste products) in an equally effective, efficient, ***safe and sustainable manner.***

Legend:

- Highlighted in *italics* = what is new.
- **Bold** highlighted = what is particularly important.

4. Conclusion

The research work will contribute to basic research in the field of logistics planning. It will subsequently be used in education and training and as a basis for various research projects in logistics. New research questions will be raised.

For example, there is still a considerable need for research in the area of delimitation, definition and classification of planning tasks. Furthermore, the question arises, which new planning rules can be established?

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