intersemiotic relations in multimodal text

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theory and methodology

Sabine Bartsch
Technische Universität Darmstadt
Institut für Sprach- und Literaturwissenschaft
URI: http://www.linglit.tu-darmstadt.de
E-Mail: {lastname}@linglit.tu-darmstadt.de

overview

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- multimodal communication in science and engineering
- multimodal corpus studies
- intra- and intersemiosis in scientific documents
- conclusions and outlook

studies of the language of science and academia

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- research on language for special purposes (LSP) and language for academic purposes (LAP)
  - technical vocabulary and terminology
  - hedging
  - self-construal of the scientist in scientific papers
  - lexicogrammar: nominalisation, grammatical metaphor etc.
  - register profiling (Biber et al.)
  - expression of stance (Biber 2004; Hyland 1988)

studies of the language of science and academia

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- insights into the linguistic construal of scientific meaning and its shift in the course of the historical development of the sciences (e.g. Halliday 1988; Halliday & Martin 1993; O'Halloran 1999; 2004)
- register studies of engineering texts (Bartsch 2004; Bartsch et al. 2005)

multisemiosis
in science and engineering

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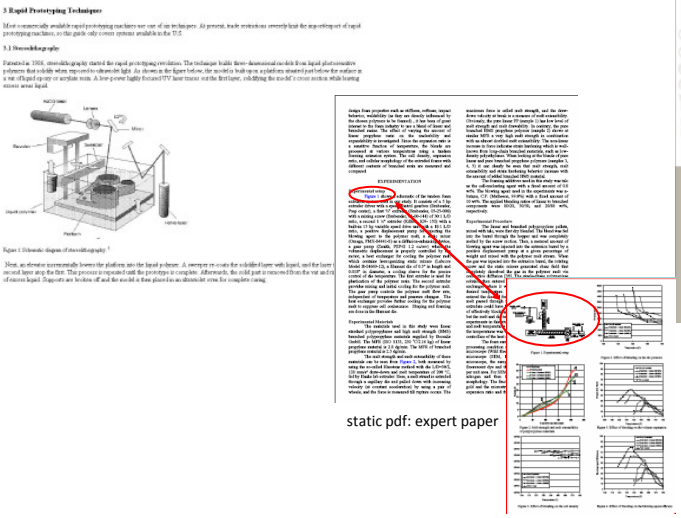

static pdf: expert paper

interactive pdf: model of a turbine

multisemiosis
in science and engineering

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- central aspects have been largely ignored by studies of scientific and academic text:
  - visual artefacts such as images, schematic figures etc.
  - symbolism (symbolic representations, formulae etc.)
  - textual organisation, esp. including the role of other semiotic resources

- self-characterisation of a mechanical engineer: „the drawing is the language of the engineer“ (Reiner Anderl, TU Darmstadt)

multisemiosis in science and engineering

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„[…] every linguistic act, spoken or written, takes place over more than one 'mode' or channel of communication“

„The study of ‘monomodal’ texts traditional in linguistics and other text-based investigations is thus revealed as an abstraction whose validity is questionable.“

(Bateman et al. 2002)

research questions

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- how does a discipline construe meaning?
- how is domain knowledge construed by means of different semiotic resources, i.e. by multisemiosis?
- how is multisemiosis instantiated in documents of the target domain?
- what are the mechanisms that account for the joint contribution of different semiotic resources to the meaning of a multimodal document?

multisemiosis in science and engineering

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- target domain: data processing in construction, a subdomain of mechanical engineering

- semiotic resources:
  - natural language
  - visual representations such as pictures, schematic figures, sketches etc.
  - symbolic representations: formulae, diagrams etc.
  - intermediary forms: tables, representations of data structures
  - virtual models such as CAD (Computer Aided Design) models

multisemiosis in science and engineering

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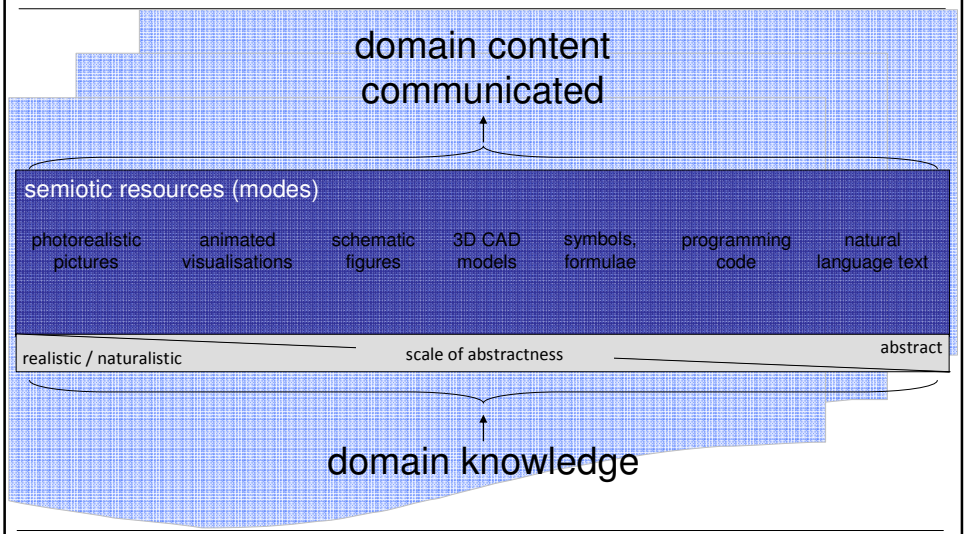

research issues

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- characterisation of the individual semiotic resources
- characterisation of their individual and joint contribution to the meaning of the overall document
- characterisation of the interaction between them

research desiderates

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- integrated multisemiotic view of scientific text
- studies covering larger amounts and more types of multisemiotic texts
- theoretical and methodological foundation for multisemiotic register studies

theory

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- Systemic Functional Grammar (SFG) (Halliday 2004)
- SF-Multimodal Discourse Analysis (SF-MDA) (O'Halloran 2004b)
- X-MDA
- Register linguistics (Halliday & Hasan 1989; Biber et al. 1995; Martin 1985)

theory:
SFG as a theory of intersemiosis

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metafunctions	mode of meaning	Examples for language: (various ranks)
ideational: logical experiential	construe experience as meaning	taxonomic chains (lexis) lexis (word), transitivity (clause)
interpersonal	enact social roles and relations	mood (clause)
textual	modulate ideational and interpersonal meaning as „flow of information"	theme-rheme (clause), coherence (text)

methodology

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- corpus and computational linguistics
- multilayer XML annotated corpora
- xlink / xpointer to establish intersemiotic links
- tools working with standard XML encoding for annotation and query

multi-layer XML-encoded corpus

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- field: data processing in construction
  a subdomain of mechanical engineering
- tenor: expert-to-expert, expert-to-learner,
  learner-to-teacher, expert-to-user/customer
- mode: written-to-be-read
- genres:
  - research articles
  - lab reports
  - book chapters
  - (instructional) web pages
  - technology presentations

corpus

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- semiotic resources:
  - text (~ 1.7 mio. running words)
  - visual representations (~ 780)
  - tables (~ 300)
  - diagrams
  - virtual 2D and 3D CAD models (~ 20)
  - formulae , numerical data (unknown, yet)

corpus: overview

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	expert-to-expert	expert-to-user	expert-to-learner	student-to-teacher
research articles	X			
lab reports	X			X
book chapters	X		X	
(instructional) web pages	X	X	X	X
technology presentations	X	X		

corpus: semiotic resources

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	text	visual representation	symbolic representation	intermediary types	virtual models
research articles	X	X	X	X	X
lab reports	X	X	X	X	X
book chapters	X	X	X	X	
instructional web pages	X	X	X		
technology presentations	X	X		X	X

levels of multisemiotic analysis

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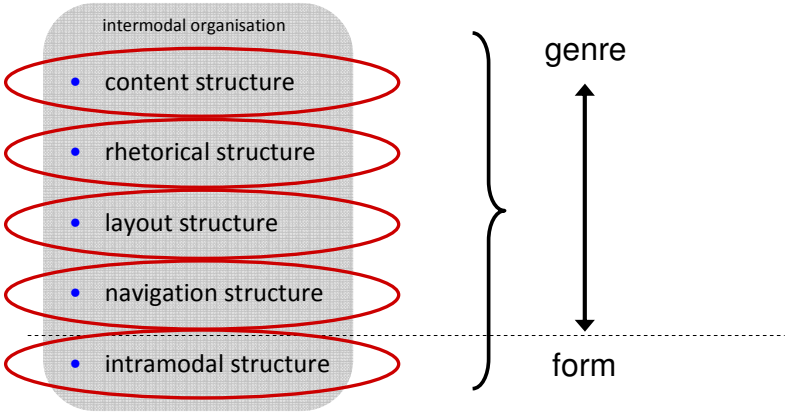

adapted from the GeM model (Bateman et al. 2001)

levels of multisemiotic organisation

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- intrasemiotic organisation
  - organisation of meaning within each semiotic resource
- intersemiotic organisation / intersemiosis
  - organisation of semiotic resources within multimodal documents

multisemiotic text analysis: intrasemiotic organisation

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ideational metafunct.	natural language	tables	programming code	symbolism: symbols, formulae	2D and 3D models	schematic figures	photorealistic images
experiential meaning	lexicogrammar: vocabulary, terminology	→	under study	symbols, numerical data	objects, process representations		
	transitivity: process types, participants, circumstances		under study	participants and operators	participants, processes / actions, circumstances		
logico-semantic relations	expansion, projection	Various, Lemke 1998b	under study		expansion, projection		

multisemiotic text analysis: intrasemiotic organisation

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	natural language	tables	programming code	symbolism: symbols, formulae	2D and 3D models	schematic figures	photorealistic images
interpersonal metafunction	mood, modality	colour, shading, framing, highlighting	commentary		colour, shading, framing, highlighting		
textual metafunction	lexical cohesion, grammatical cohesion, conjunctive relations	arrangement	indentation, object orientation (classes)			visual cohesion	

intrasemiotic organisation: linguistic text analysis

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situational parameters	field, tenor, mode		
lexis	terminology collocations		
grammar	transitivity	process types	material, relational, mental, existential, behavioural, verbal
		participants	actor, goal etc.
		circumstantial elements	time, place, manner
textual structure	cohesion thematic structure rhetorical structure generic structure		logico-semantic relations process type distribution

corpus annotation: linguistic annotation

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- ideational features in language
  - PoS-tagging (Stanford NLP Tools)
  - syntactic parsing (Stanford NLP Tools)
  - lexical analysis
  - transitivity: ideational features (UAM CorpusTools; O'Donnell 2007)

  } automatic annotation

- textual features in language
  - lexical cohesion
  - Rhetorical structure (RSTTool; O'Donnell 2001)

  } semi-automatic + manual annotation

⇨ some of these annotations are extensible to other semiotic resources: e.g. transitivity, lexical cohesion, RST

metadata for schematic figure: experiential description

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- PARTICIPANT: AGENT: laser beam
  PROCESS: CHANGE-STATE fuse
  PARTICIPANT: powdered materials
  GOAL: into a solid object
- PARTICIPANT: AGENT: laser
  PROCESS: ACTION MOVEMENT: traces
- PARTICIPANT: the pattern,
  GOAL: sintering it together
- TRAJECTORY: vector, directionality

visual semiotic resource annotation

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Objects	PARTICIPANT: ACTOR PARTICIPANT: GOAL:	laser powdered materials into a solid object
Actions	CHANGE-STATE, ACTION MOVEMENT	fuse
Directionality	TRAJECTORY: vector, directionality	direction of object trajectory

```
<unit id="u-01.119">
    <object function type=„participant-actor“>laser
       </object>
    <action function type=„change-state">fuse
       </action>
    <trajectory type=„uni-directional“</trajectory>
</unit>
```


intersemiosis in science texts

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	verbal	intersemiosis	visual
ideational	terminology, collocations processes, participants, (attributes), circumstances logico-semantic relations	intersemiotic phoric links; intersemiotic cohesion; transitions (macro- and microtranisations) logico-semantic relations	visual transitivity: actions objects, (attributes) logico-semantic relations
interpersonal	modality, modulation	framing, highlighting of related participants or processes across srs	color, shading, etc.; interactivity features
textual	lexical cohesion, grammatical cohesion, conjunctive relations	intersemiotic reference, intersemiotic recurrence, repetition, substitution, ellipsis, rhetorical structure relations	visual cohesion, (explicit) sequencing,

interactional features: hyperlinks, sequencing, menues, buttons, clickable areas

intersemiosis: categories of a model

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- status of semiotic resources: equal | unequal
- logico-semantic relations
  - expansion
  - projection
- intersemiotic cohesion
  - repetition of the same concept in different modes
  - substitution of one mode for another, same concept
  - paraphrasing of a concept in another semiotic resource
- semiotic transition
  - micro-tarnsitions
  - macro-transitions

inter-modal relations: status of modes

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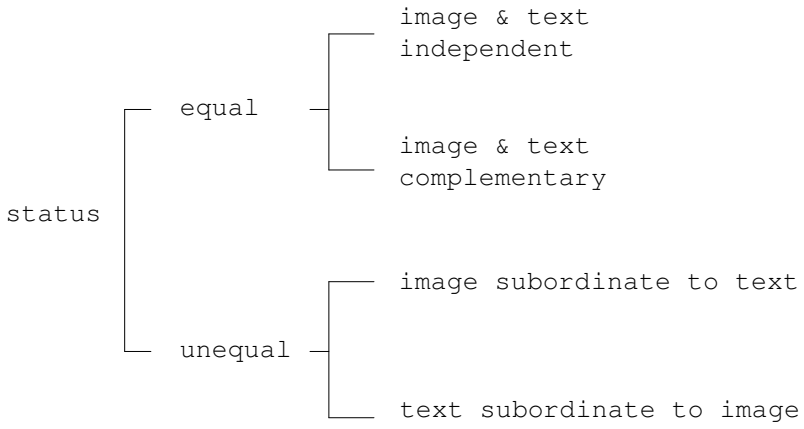

inter-modal relations: logico-semantic relations

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- logico-semantics:
  - expansion:
    - elaboration (elaboration on the meaning of another unit by a more detailed description of it)
    - extension (extension of the meaning of another unit / mode by adding further, related information)
    - enhancement (of a mode by qualifying it in terms of time, place, cause, and other circumstantial meanings)
  - projection

⇨ possibility of extension of these relations to further discourse units and other modes such as images, tables, formulae, 3D models etc.

inter-modal relations: logico-semantic relations

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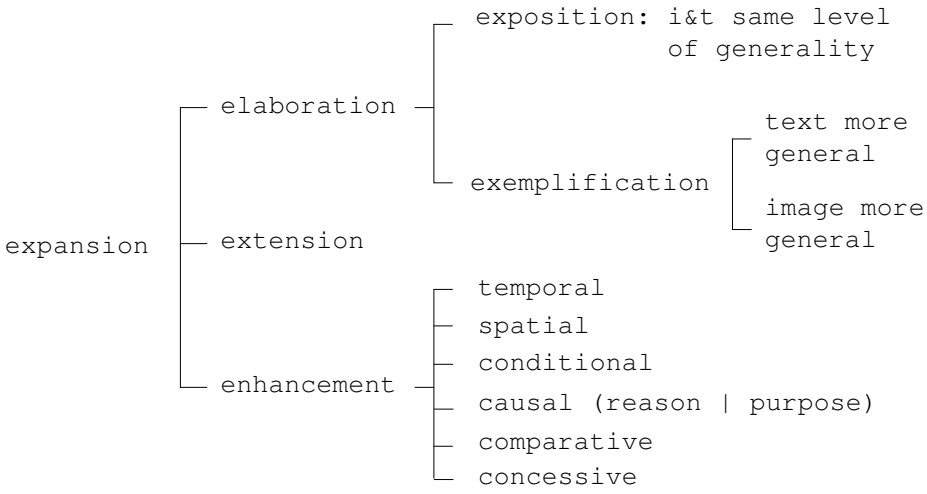

intersemiotic reference: explicit reference

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- intermodal phoric links
  as shown in, as exemplified in, ...

  … as depicted in Figure x.x:

  Single-Point Cutting-Tool Geometry. Figure 13.2.3 depicts the location of various angles of interest on a single-point cutting tool.

→ used rather unspecifically, no good indicator of image function

intersemiotic reference: explicit reference

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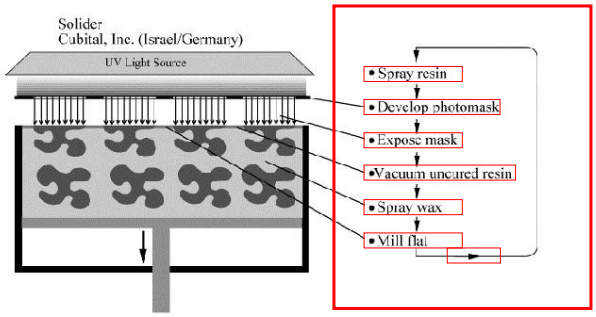
- Structures of interaction between modalities
  - Links between text and visual modality
    - Crossmodal referring expressions
      reference to document parts / sections (e.g. „Fig. 1“)
    - Multimodal referring expressions
      object reference by means of more than one modality
    - Anaphoric referring expressions
      reference to previously introduced objects in abbreviated form

cf. André, Rist 1994

3.4 Solid Ground Curing

Developed by Cubital, solid ground curing (SGC) is somewhat similar to stereolithography (SLA) in that both use ultraviolet light to selectively harden photosensitive polymers. Unlike SLA, SGC cures an entire layer at a time. Figure 5 depicts solid ground curing, which is also known as the solider process. First, photosensitive resin is sprayed on the build platform. Next, the machine develops a photomask (like a stencil) of the layer to be built. This photomask is printed on a glass plate above the build platform using an electrostatic process similar to that found in photocopiers. The mask is then exposed to UV light, which only passes through the transparent portions of the mask to selectively harden the shape of the current layer.



multimodal referring expressions

Figure 5: Schematic diagram of solid ground curing. [11]

crossmodal referring expressions

After the layer is cured, the machine vacuums up the excess liquid resin and sprays wax in its place to support the model during the build. The top surface is milled flat, and then the process repeats to build the next layer. When the part is complete, it must be de-waxed by immersing it in a solvent bath. SGC machines are distributed in the U.S. by Cubital America Inc. of Troy, MI. The machines are quite big and can produce large models.

intersemiotic reference: grammatical metaphor

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- verbal indicative phrases in text vs. imperative phrases in picture

"photosensitive resin is sprayed on the build platform"

vs.

"spray resin"

grammatical metaphor

Anaphoric referring expressions

intersemiotic cohesive chains and clusters: objects in different semiotic resources

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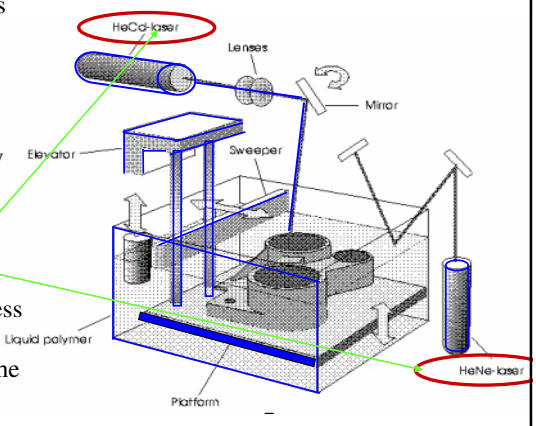
The technique [stereolithography] builds three-dimensional models from liquid photosensitive polymers that solidify when exposed to ultraviolet light. As shown in the figure below, the model is built upon a platform situated just below the surface in a vat of liquid epoxy or acrylate resin.
A low-power highly focused UV laser traces out the first layer, solidifying the model's cross section while leaving excess areas liquid. Next, an elevator incrementally lowers the platform into the liquid polymer. A sweeper re-coats the solidified layer with liquid, and the laser traces the second layer atop the first.

repetition



text more general than image

intersemiotic cohesive chains and clusters: processes in different semiotic resources

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The technique [**stereolithography**] builds three-dimensional models from liquid photosensitive polymers that solidify when exposed to ultraviolet light. As shown in the figure below, the model is built upon a platform sit[illegible]he surface in a vat of liquid epoxy or acrylate resin.
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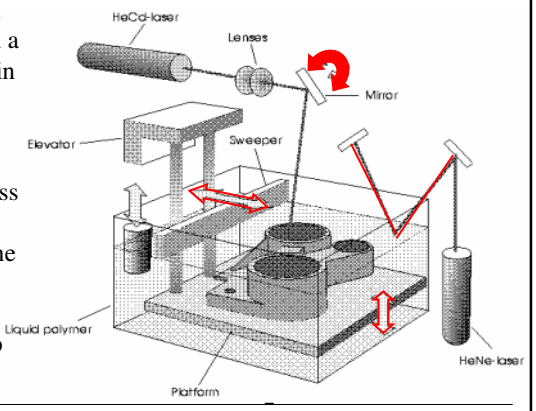
complex repetition

image more general and unspecific than text



intersemiotic cohesive chains and clusters: objects in different semiotic resources

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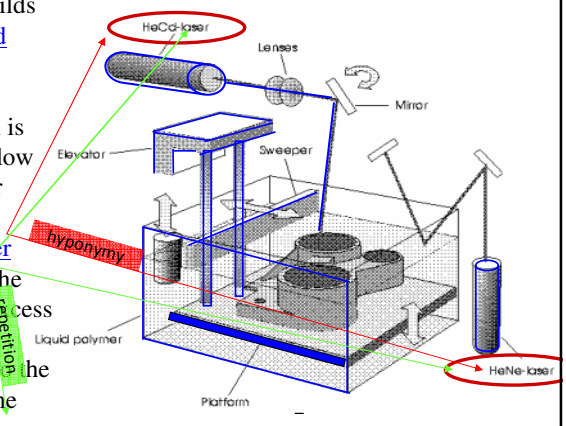

text more general than image

intersemiosis: semiotic transition

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- semiotic transition
  - micro-tranistion:
    functional elements from one semiotic resource are contained within another semiotic resource
    example: symbols used in graphs,
    language used in formulae or schematic figures
  - macro-transition:
    items consisting of one semiotic resource are replaced by items comprised of another semiotic resource
    example: language → table → visual image (graphs) → symbolism (e.g. formula)

O'Halloran (2004a)

corpus annoation

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```
<unit id="u-01.106">3.2 Laminated Object
Manufacturing</unit>
<unit id="u-01.109"><xlink:href="//gemBase/unit[@id='u-
01.118']" role="text-to-image" from=„u-01.109“ to=„u-01.118“
status=„unequal-image-subord“ logsem=„enhancement-temporal“
cohesion=„complex-paraphrase“/>As shown in the figure below,
a feeder/collector mechanism advances the sheet over the
build platform, where a base has been constructed from paper
and double-sided foam tape. </link></unit>
<unit id="u-01.118" alt="Bilder/Figure2“ objects=„laser
mirror platform collector …“ processes=„vertical_move
horizontal_move“/>
<unit id="u-01.119">
   <xlink:extended role="caption" title="figure caption">
   <xlink:locator href="//gemBase/unit[@id='u-
01.118']"/>Figure 2: Schematic diagram of laminated object
manufacturing.</xlink:extended></unit>
```


conclusion & outlook

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- multisemiosis is pervasive in scientific and engineering texts
- and will become even more central with the advent of new computational construction methods
- It can be described in terms of extended notions of cohesion and transition, but more work needs to be done especially with the advent of new forms of documents …

Example: interactivity and cohesion in 3d-pdf

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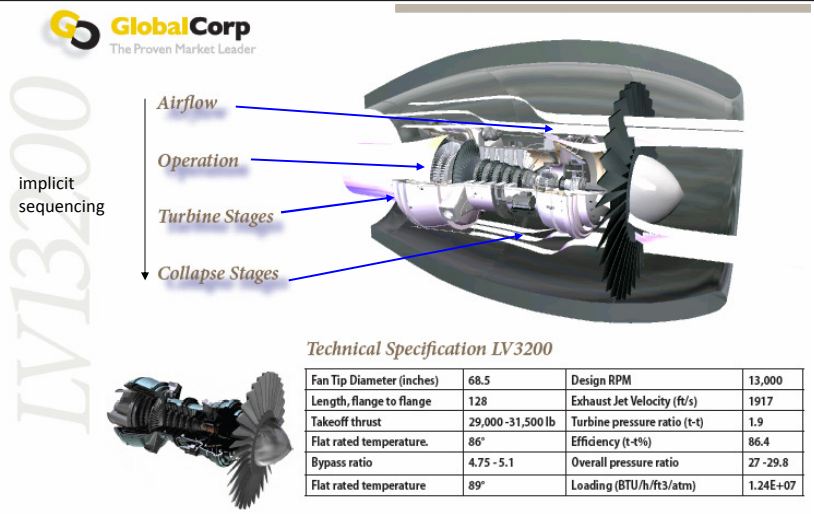

Technical Specification LV3200

Fan Tip Diameter (inches)	68.5	Design RPM	13,000
Length, flange to flange	128	Exhaust Jet Velocity (ft/s)	1917
Takeoff thrust	29,000 -31,500 lb	Turbine pressure ratio (t-t)	1.9
Flat rated temperature.	86°	Efficiency (t-t%)	86.4
Bypass ratio	4.75 - 5.1	Overall pressure ratio	27 -29.8
Flat rated temperature	89°	Loading (BTU/h/ft3/atm)	1.24E+07

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