# Measuring and Improving the Completeness of Natural Language Requirements

Alessio Ferrari[1] Felice dell'Orletta[2]
Giorgio O. Spagnolo[1] Stefania Gnesi[1]

[1]ISTI-CNR (Formal Methods and Tools Lab), Pisa, Italy
http://fmt.isti.cnr.it

[2]ILC-CNR (ItaliaNLP Lab), Pisa, Italy
http://www.italianlp.it

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# What is Completeness of a SRS?

## Completeness

An SRS is complete if nothing is missing from the specification


## Nothing is missing with respect to WHAT?

Different perspectives shall be considered...

# Internal and Forward Completeness

## Internal completeness

Nothing is missing with respect to the specification itself

- No To-be-determined (TBD) items
- No nonexistent references

Requires guidelines or templates

## Forward completeness

Nothing is missing with respect to the system-to-be

- No missing specification items (e.g., missing interface specifications)
- No missing functions
- No missing products (i.e., part of the actual software that are not mentioned in the specification)

Requires a model of the system

# Backward Completeness

## Backward Completeness

Nothing is missing with respect to what comes before the SRS

## What comes before the SRS?

- Transcripts of meeting with customers
- Preliminary specification documents
- Reference standards
- Legacy documents

# Research Questions

- **RQ1.** How to **measure** the backward completeness of a requirements specification document?
- **RQ2.** How to **improve** the backward completeness of a requirements specification document?
- **RQ3.** Does the backward completeness **help** in improving the forward completeness of the specification?

# Measuring Completeness

# Defining complete requirements for a rock band

**Rock'n Roll**

In the earliest rock and roll styles of the late 1940s and early 1950s, either the **PIANO** or saxophone was often the lead instrument, but these were generally replaced or supplemented by GUITAR in the middle to late 1950s. The **BEAT** is essentially a **BLUES RITHM** with an accentuated **BACKBEAT**, the latter almost always provided by a snare drum. Classic rock and roll is usually played with one or two **ELECTRIC GUITARS** (one lead, one rhythm), a string bass or (after the mid-1950s) an **ELECTRIC BASS GUITAR**, and a **DRUM KIT**.


**Requirements for My Band**

- My Band shall have **ELECTRIC GUITARS**
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# Backward Completeness

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All the relevant **concepts** and **interactions** among concepts expressed in the input documents are also treated in the requirements

We distinguish between:

- Concept Completeness
- Interaction Completeness

# Concept Completeness

## Relevant Terms

- Relevant concepts can be approximated with the relevant terms of the input documents
- A term is a single word (e.g., “guitar”) or a multi-word term (“rock and roll”)

# Concept Completeness

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The PIANO!


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# Iteraction Completeness

## Relevant Relations among Terms

- Relevant interactions can be approximated with **relevant relations** among terms
- Pairs of relevant terms that occur in the same sentence of the input documents form a relevant relation
- **GUITAR** is normally a lead instrument in **ROCK AND ROLL**

# Interaction Completeness

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The BACKBEAT in the RITHM!


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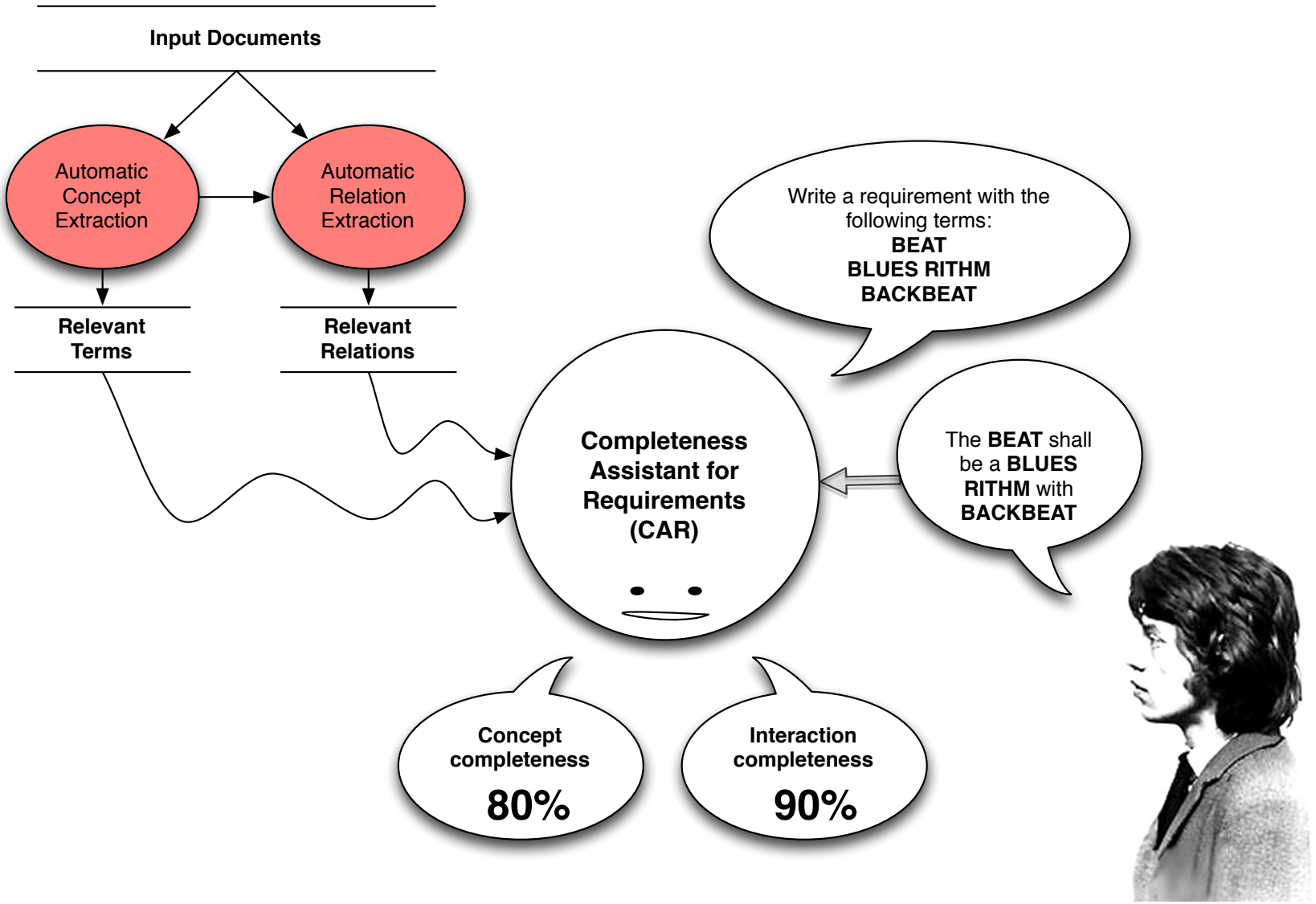
# A Word Game to Improve Completeness

# Completeness Assistant for Requirements



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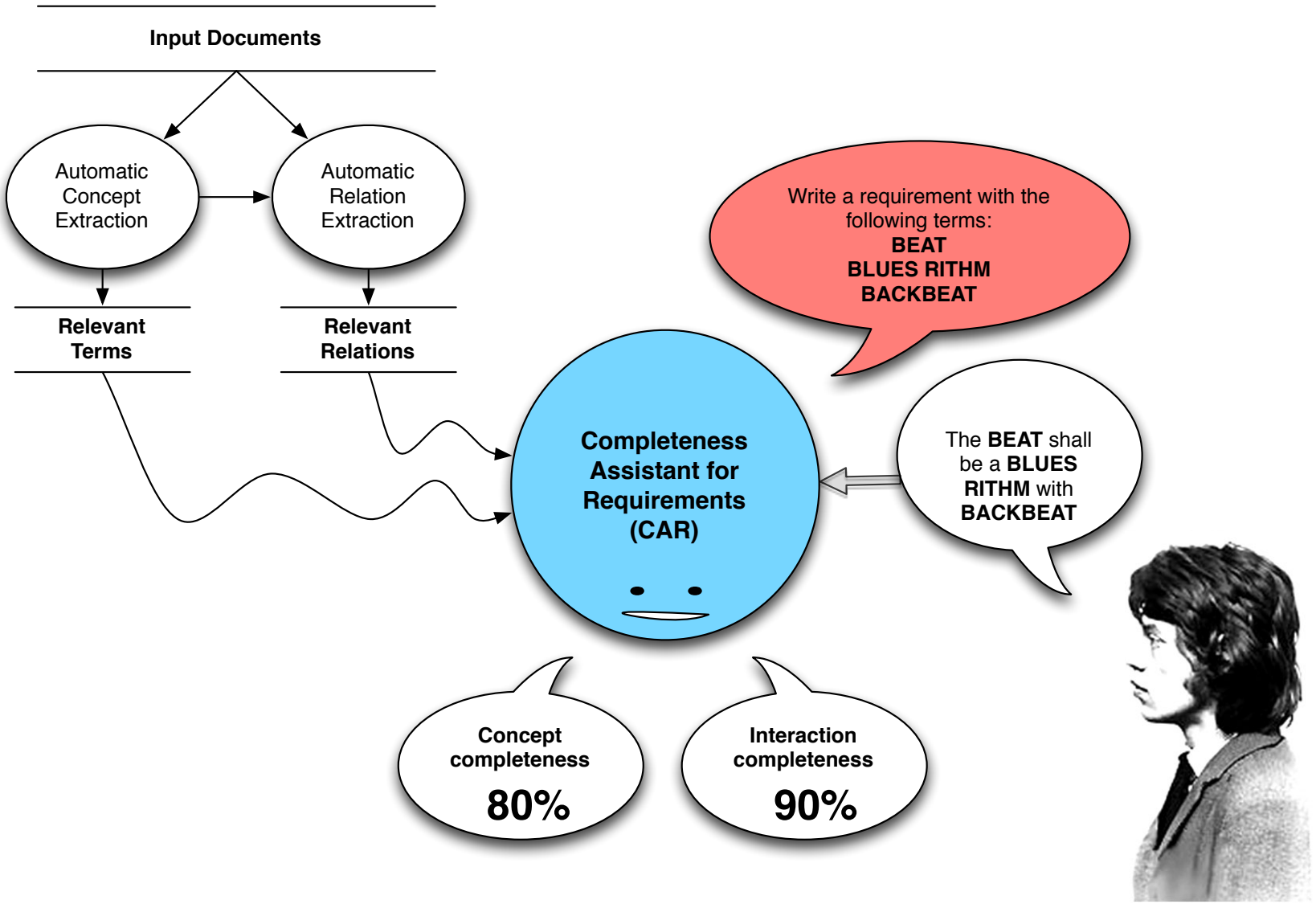

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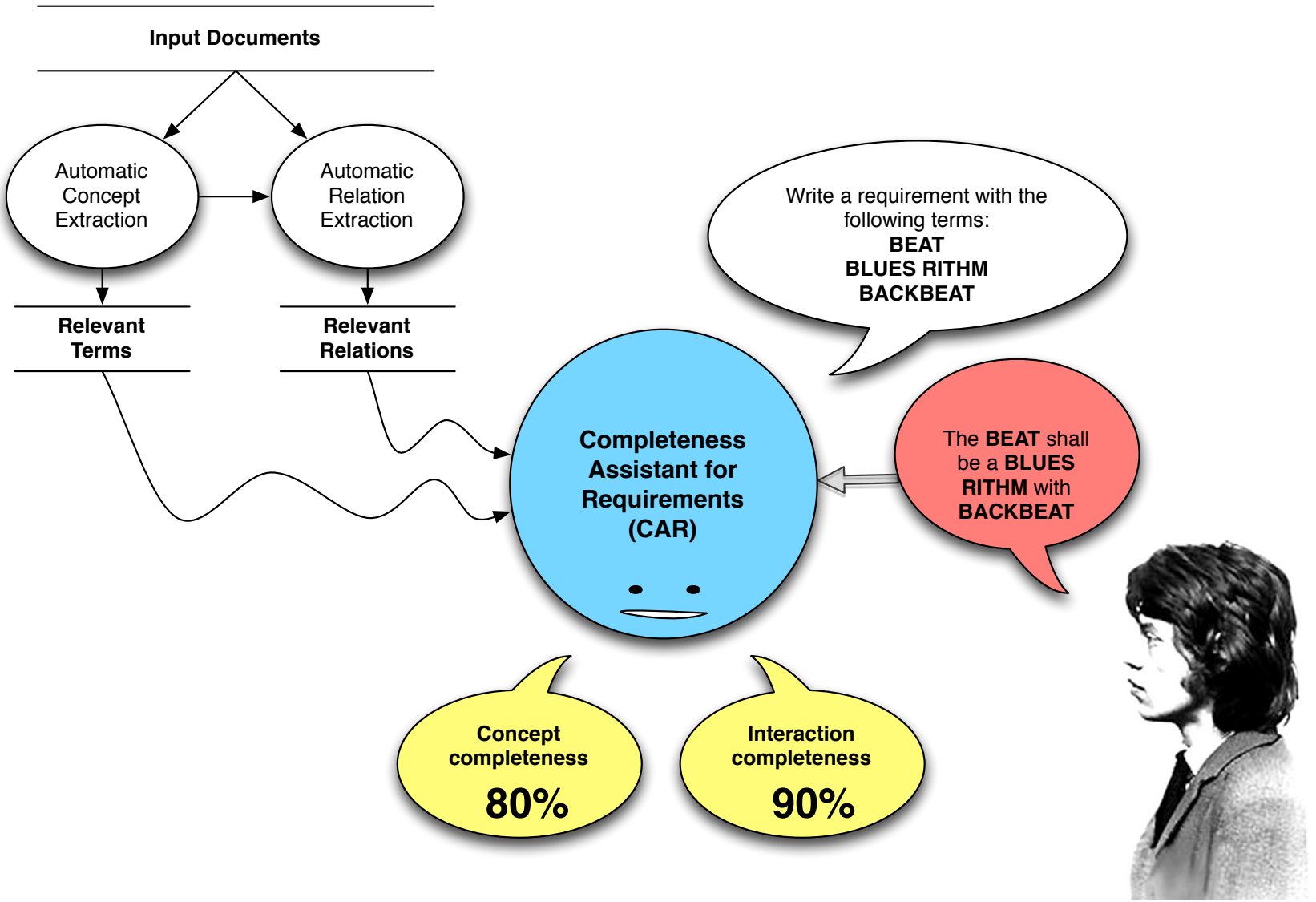

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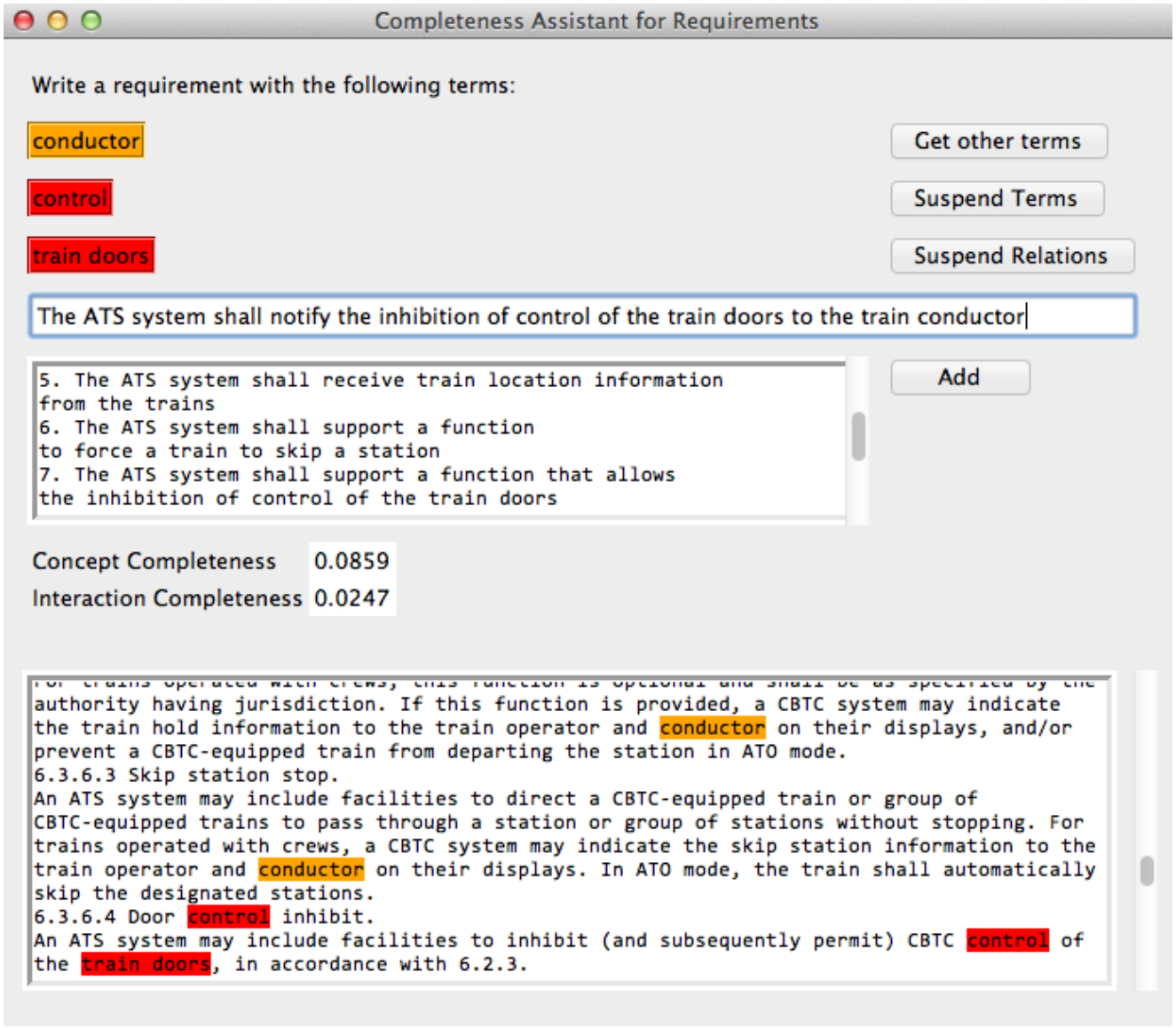


# Experiment

# Automatic Train Supervision (ATS) System

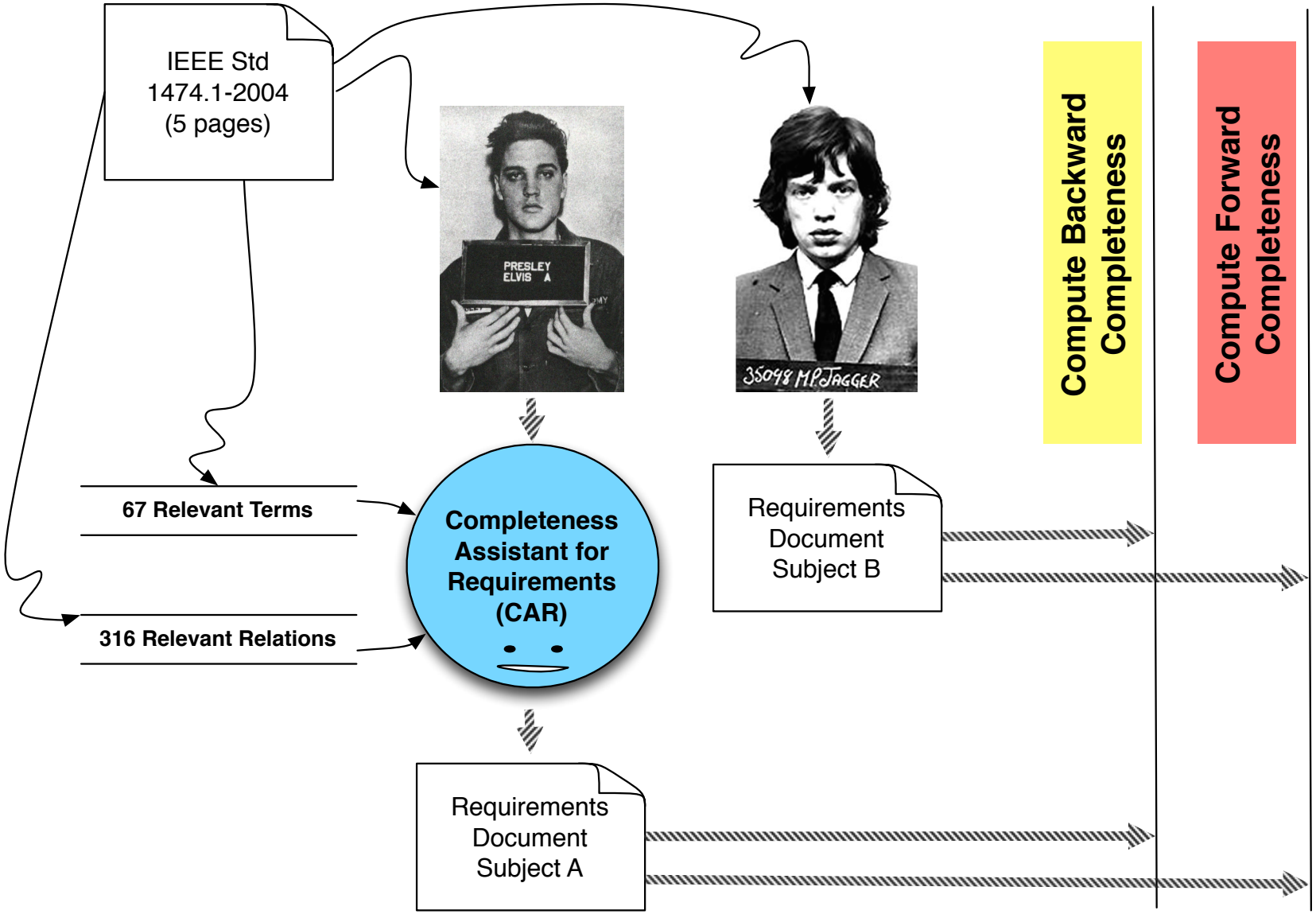
## ATS System

- Centralized system that monitors and regulates the movement of the trains
- Automatically routes trains, and sends them speed profiles that shall be followed while moving through the railway network
- Normally equipped with a user interface where the ATS operator can view the position of all the trains, their schedule, and other information

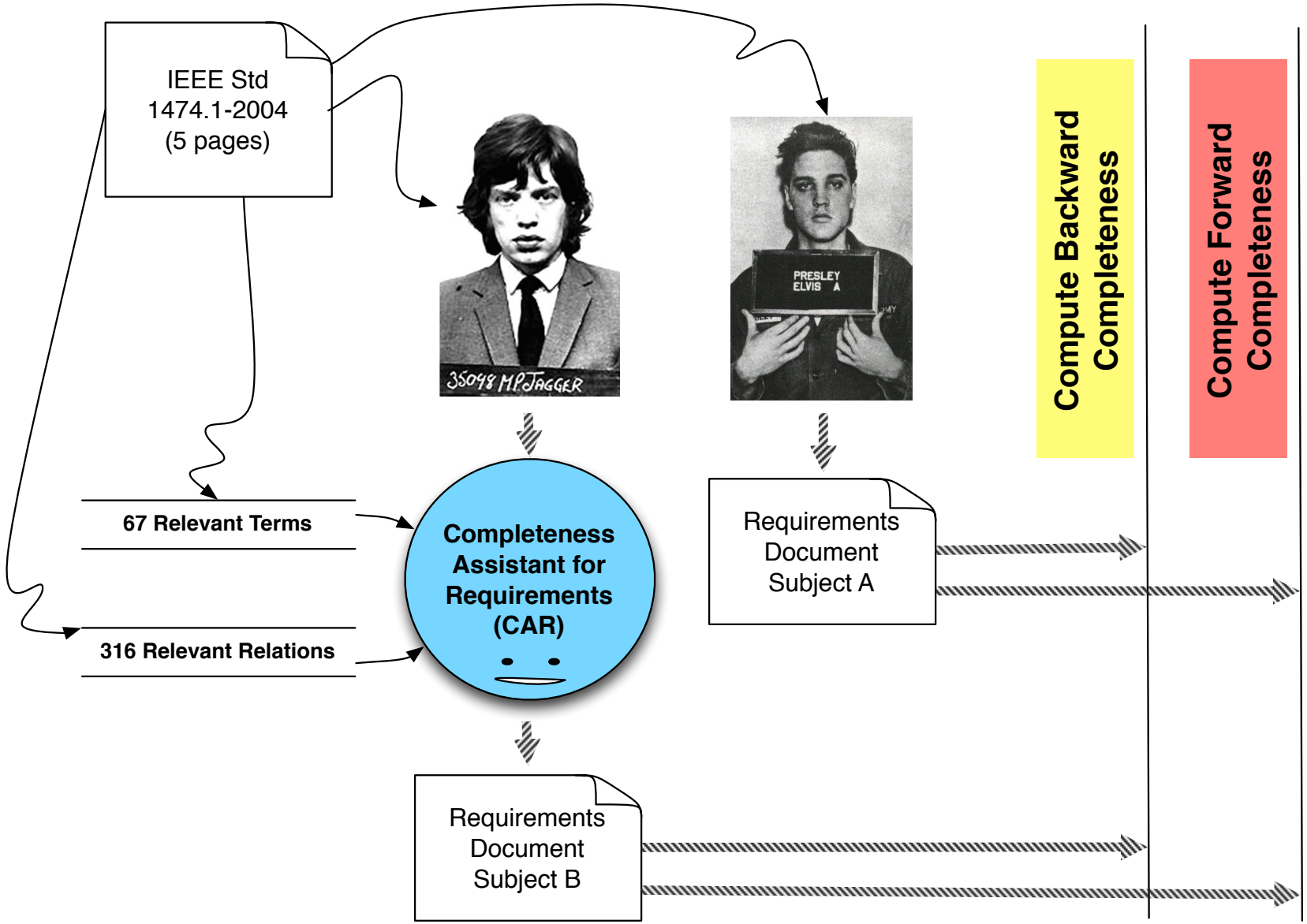
## Input Document

The IEEE Std 1474.1-2004 includes the basic requirements of an ATS system

# Experiment: Phase 1



# Experiment: Phase 2



# Results

| Subject | Num. Reqs | Tool | *degCC* | *degIC* | *degFEC* | *degLCC* |
|---|---|---|---|---|---|---|
| A | 36 | **Yes** | **68.7%** | **17.1%** | 47.6% | 40% |
| | | **No** | **52.3%** | **12.8%** | 61.9% | 50% |
| B | 21 | **Yes** | **67.2%** | **24.5%** | 47.6% | 50% |
| | | **No** | **58.2%** | **11.6%** | 33.3 % | 50% |

Backward completeness increases when the tool is used

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- We did not find a positive correlation between backward and forward completeness
- A positive correlation holds only for Subject B

# Conclusion

- A new method has been developed to measure completeness
- A new method has been developed to improve completeness

- Backward completeness did not imply forward completeness
- Requirements definition needs **background + [...]** to achieve forward completeness

- The requirements edited with CAR tend to be more specific
  - "The ATS system shall adjust the speed profile of the trains in response to wet rail conditions in order to avoid emergency brake application" (**specific case**)
  - "The ATS system shall be capable of supporting re-routing of trains in response to service disruption" (**alternative behaviour**)
- The tool can have a complementary role in requirements definition

# Questions?

E-mail: alessio.ferrari@isti.cnr.it

FMT Group: http://fmt.isti.cnr.it
ItaliaNLP Group: http://www.italianlp.it