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2 rue Robert d'Arbrissel CS 76522
35065 RENNES CEDEX
FRANCE
Tél. +33 (0)2 99 54 63 63
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Knowledge Diffusion in a Specialist Organization: Observational and Data-driven Case Study

Dr. Mounir Kehal
Mounir.Kehal@ESC-Rennes.fr

www.esc-rennes.fr
Research Faculty & Asst. Prof. @
***école Supérieure de Commerce* RENNES SCHOOL OF BUSINESS**
Rennes, Brittany
FRANCE

Talk Plan

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- Introduction
- Motivation & Justification
- Hypothesis & Methodology
- Observational Study
- Data-driven Case Study
- Research Evaluation and Outlook
- Concluding Remarks

Introduction

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- Knowledge may be regarded as a function of beliefs, theories, and/or practices – to say the least

- Displacement of knowledge may cause creation / adoption or adaptation, of new knowledge (on consensus but different approaches)

- Domain specific language may outlay characteristics of specialism contained
    - Abounding with specialist terms, that some may be emergent

- Flow of knowledge amongst peers may need continuous monitoring and facilitation at different stages of the diffusion of the knowledge of domain

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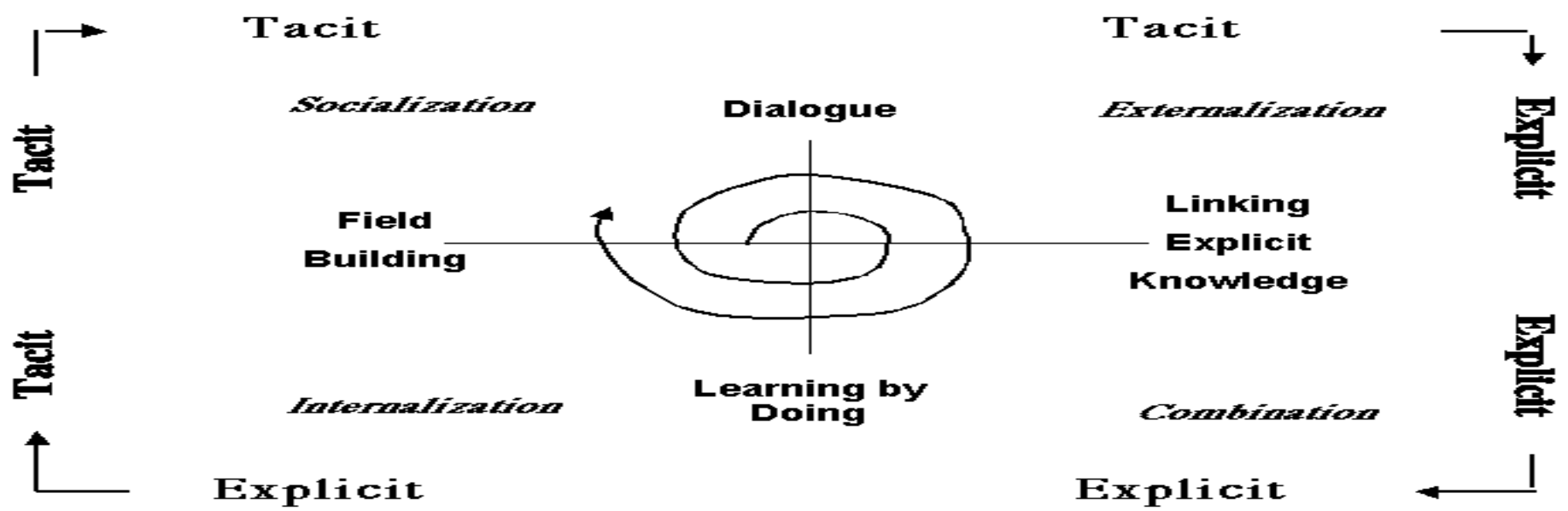
Introduction

Five phase model of the organization knowledge creation process

- Sharing of tacit (explicit) knowledge
- Creating concepts
- Justifying concepts
- Building an archetype
- Cross levelling of knowledge



Nonaka, I. and Takeuchi, K. (1995) The Knowledge Creating Company: How Japanese Companies create the Dynamics of Innovation, Oxford University Press, Oxford.

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Motivation & Justification

Areas of contribution,

- **How to manage the growth and diffusion of knowledge within a growing organization (SME as a case).**
  - ***Investigating applicability of knowledge conversion model (intuitive approach) in the management of knowledge (re: empirical approach) being carried in an SME***
  - SMEs creation of dynamics of innovation
  - Diffusion of knowledge between different organizations of shared interests
  - Investigating utilization of knowledge following its creation
  - R&D on networked environments (computer-mediated) to index knowledge repositories available, by validation of the expert-user within the specialist domain.

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Motivation & Justification

- A field project within the context of a spin off enterprise (SME, Small to Medium Enterprise) was conducted (re: EU typology)
- Attempt to identify through comparative and diachronic studies how research documents (science: theories, assumptions, fundamental knowledge: i.e. higher education institution) feed onto commercial documents (business: models, practices, applied knowledge: i.e. spin-off of higher education institution)
- Organizational structures supporting the flow of knowledge and its adaptation within the same domain of application (s) of science, through the observational study (SSTL)

Research Hypothesis

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- **This research empirically investigates the creation of new technical knowledge**

- Knowledge Diffusion, a flow and an adaptation process through text

- Extend Nonaka *et al*'s (1995) organisational knowledge creation theories (*knowledge conversion model*) into the area of research and development ventures, within LEO satellite manufacturing

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Research Hypothesis

- Understanding and identifying how scientific knowledge is converted into the knowledge of a business application
  - as a mechanism for an SME to create dynamics of innovation

- We have used a model for the conversion of scientific research into a business enterprise (knowledge conversion model, Nonaka et al 1995)
  - Flow and adaptation of specialist knowledge from research documents onto commercial documents

- Focus only on such conversion of research documents to commercial documents

Methodology

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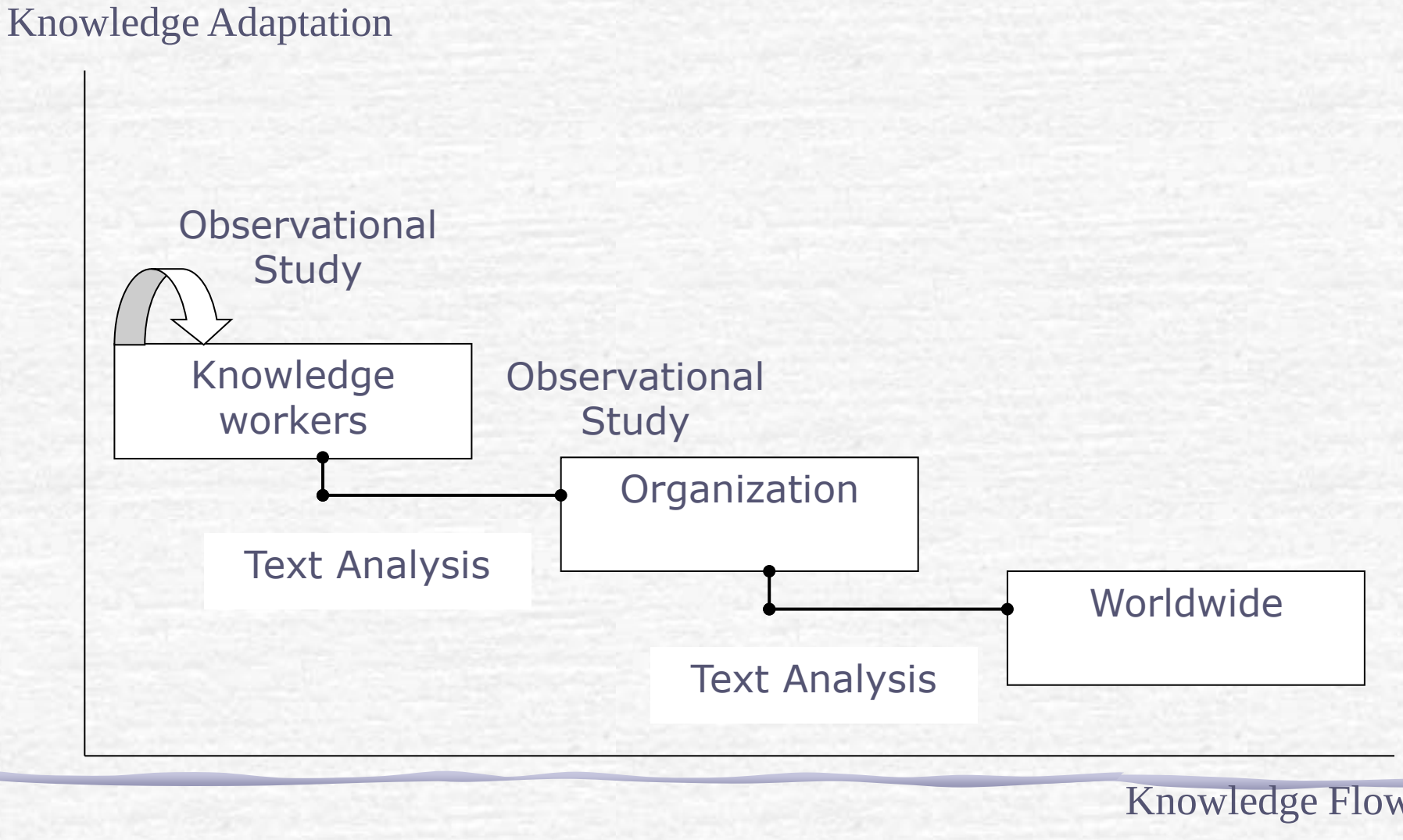
Knowledge Diffusion in a Small Organization



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Methodology

Knowledge diffusion in the environment of a small organization

Agent A	Agent B	Artefact	Technique
Person	Person	Opinion, practice, know-how, organizational structures	Questionnaire -based
Person	Organization	PhD Dissertation, Research Publications, technical reports	Text Analysis
Organization	organization	Specialist documents (i.e. technical documents, technology-specific documents, missions documents)	Text Analysis
Organization	Worldwide	Specialist documents (i.e. technical documents, technology-specific documents, missions documents)	Text Analysis

Methodology

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Data-Driven Case Study

- Collect a random sample of text corpora in a domain (may include sub-domains). That of investigation: satellite manufacturing
- Frequency analysis for single and compound specialist terms

- Study semantic relationships
  - ***hyponymy (type of)***: micropropulsion (type of propulsion)
  - ***metonymy (kind of)*** : minisatellite (kind of satellite)
  - ***meronymy (part of)***: ionospheric (part of the sphere)
  - …
- Extract candidate ontology

- Map the ontology in a document database of the domain

Text is a trace of knowledge …

Assumption

- Frequency is a correlate of acceptability (Quirk, 1985)

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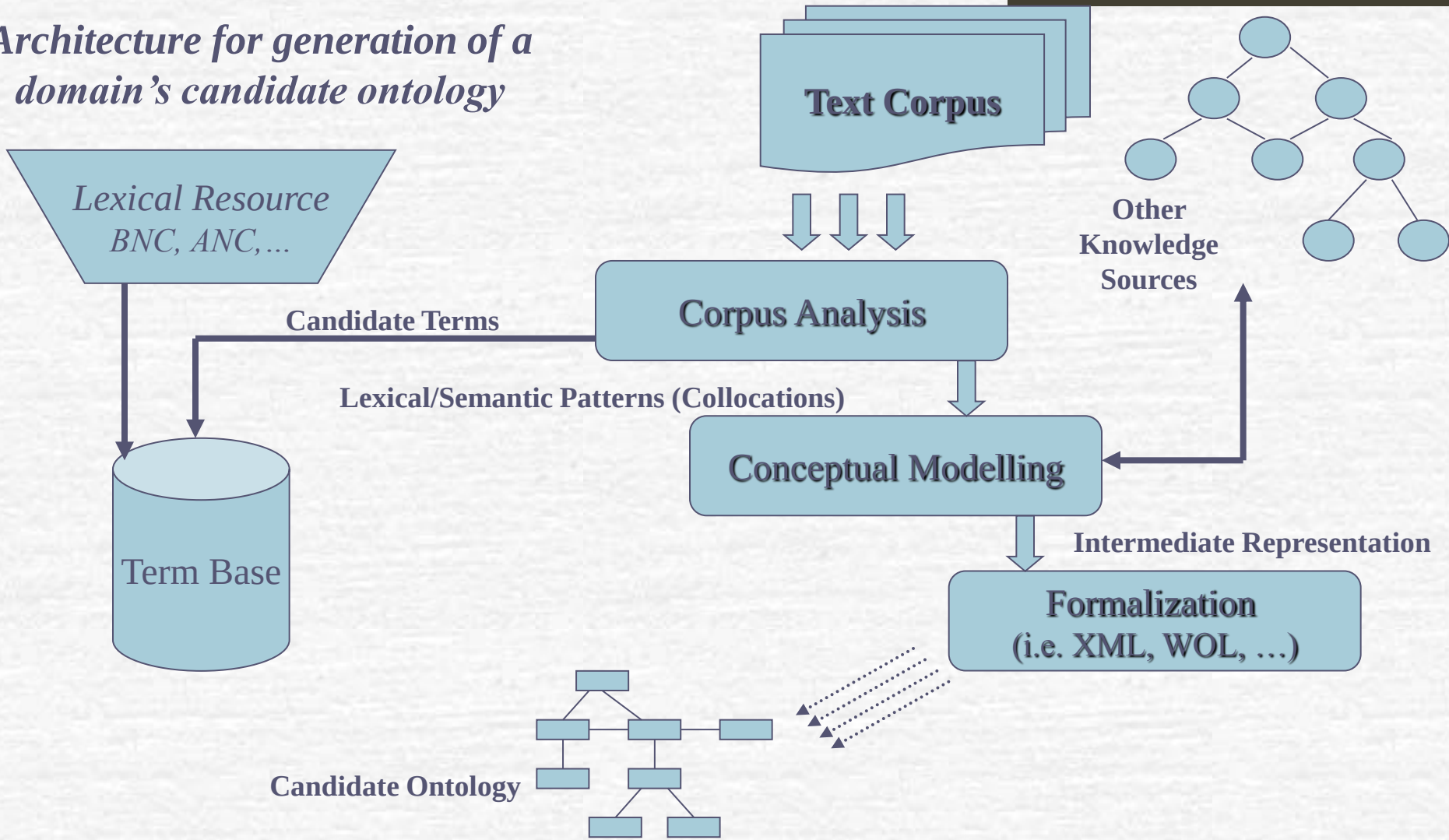
Methodology

Architecture for generation of a domain's candidate ontology



- **UoS Peers: Healthcare (Breast Cancer), Financial/Business News, Semiconductor, Scene of Crime Domains**
- **IUM: Luxury and business studies, A2B and B2A Knowledge Diffusion**
- **ESCR: eWOM in Social Web Media, High Tech NPD, A2B and B2A Knowledge Diffusion**

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Observational Study

Surrey Satellite Technology Ltd. http://www.sstl.co.uk

Surrey Satellite Technology Ltd, or SSTL, is a spin-off company of the University of Surrey, now fully owned by **EADS Astrium**, that builds and operates small satellites. Its satellites began as amateur radio satellites known by the UoSAT (University of Surrey SATELLITE) name or by an OSCAR (Orbital Satellite Carrying Amateur Radio) designation. SSTL cooperates with the University's Surrey Space Centre, which does research into satellite and space topics.

Recently SSTL has moved into remote sensing services with the launch of the *Disaster Monitoring Constellation* (DMC) and an associated child company, DMC International Imaging. SSTL also adopted the Internet Protocol for the DMC satellites it builds and operates, migrating from use of the AX.25 protocol popular in amateur radio. The CLEO Cisco router in Low Earth Orbit, onboard the UK-DMC satellite along with a network of payloads, takes advantage of this adoption of the Internet Protocol. **The UK-DMC satellite also carries a payload investigating GPS reflectometry. SSTL is also developing a new Geostationary Minisatellite Platform-Transfer orbit variant (GMP-T) aimed at the telecommunications market under the brand name SSTL-900.**

SSTL works with the British National Space Centre (BNSC) and takes on a number of tasks for the BNSC that would be done in-house by a traditional large government space agency. The University sold a 10% share of SSTL to SpaceX in January 2005. It then agreed to sell its majority share (roughly 80% of the capital) to EADS Astrium in April 2008. In August 2008 SSTL opened a US subsidiary.

Ground Control Station

SSTL was awarded the Queen's Award for Technological Achievement in 1998, and the Queen's Award for Enterprise in 2005. In 2006 SSTL won the Times Higher Education Supplement award for outstanding contribution to innovation and technology. In 2009 SSTL ranked 89 out of the 997 companies that took part in the *Sunday Times Top 100 companies to work for*.

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Observational Study

Knowledge Evolution

Technological Realization

BNSC Terminology used, for space industry segment definition

Late 1990's

Downstream offerings
Earth Observation value adding …

Late 1970's

Amateur Radio
Telecom

Early 1980's

UoSat Family

Partial
Downstream
&
Upstream

Early 1990's

Upstream:
Space & Ground
Segment

Late 1980's

Upstream:
Space Segment,
Launch Procurement

Early 2000

Space R & D & I, and Constellations

22ed Century

Observational Study

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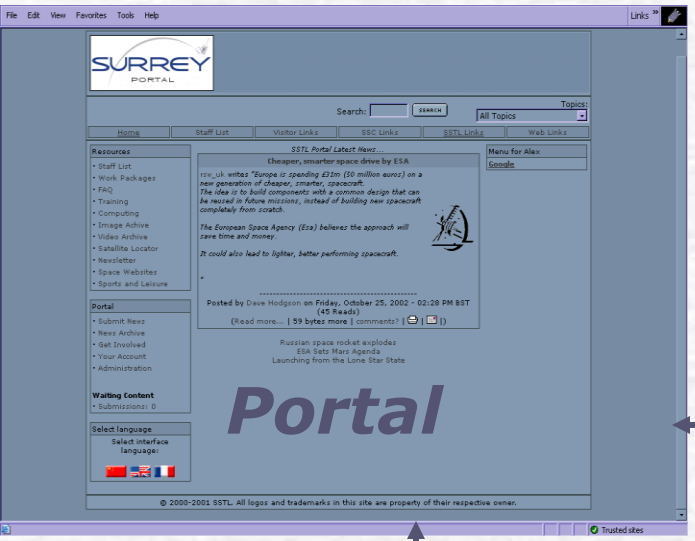

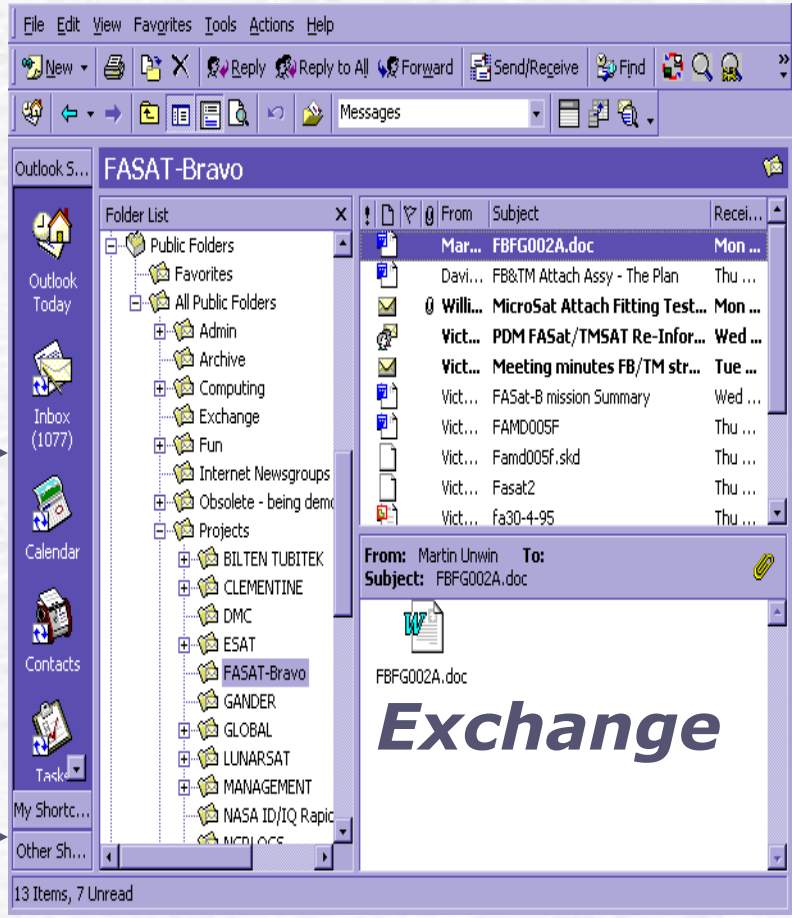

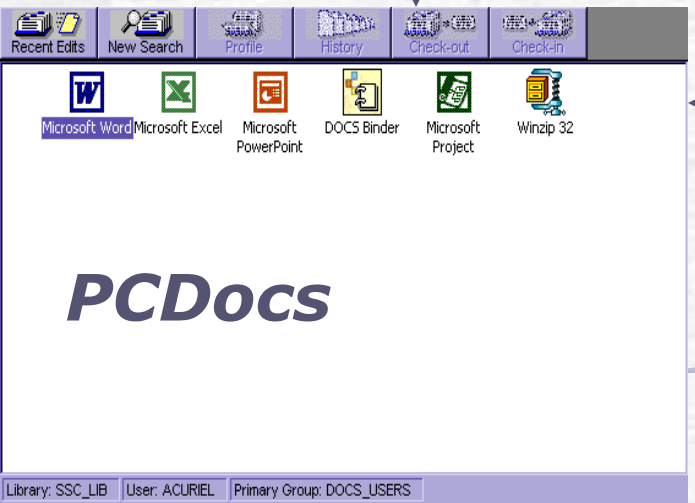

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Observational Study

Pilot Questionnaire

- Initial sample of knowledge engineers, middle managers (11 recorded responses, 17 sent)
- The Questionnaire attempted to elicit information about knowledge management in general and about four other related issues,
  - the influence of external environment
  - impact of information technology provision or otherwise
  - issues relating to maintenance and protection of knowledge, and
  - issues relating to the organization
- Each issue was further explored by a set of follow up questions

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Observational Study

The questionnaire comprised five sections:

1- Awareness and Commitment

2- External Environment

3- IT (Information Technology)

4- Knowledge Maintenance and Protection

5- Organizational Issues

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Intranet-based Survey

- The second run of the questionnaire was made intranet based, conducted onsite at SSTL
- The respondents constituted just over 30% of the total knowledge workers (52 out of 170 employees)
- Over 83% are team members and over 15% are middle to senior managers
- A relatively larger number of knowledge workers was attained

- *Question accumulated most agreement* was on Information Technology allowing effective communication across boundaries and time zones (Average Score: 4.21/5)
- *Question with least agreement* (similarly to the pilot questionnaire run) is on the existence of a "knowledge map" pointing the employees in the direction of the knowledge they are seeking (Average Score: 2.12/5)

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Observational Study

Key results

- SSTL do not perhaps encourage sharing of knowledge sufficiently or efficiently. With a tendency for bottlenecks in applying existing knowledge
- SSTL do not perhaps support gathering of business intelligence and participation in conferences sufficiently
- Knowledge workers have perhaps little time for creative thinking
- Knowledge and intellectual property are not highly values
- Seemingly, there is a lack of keeping electronic information sources up-to-date
- On a more positive side, basic IT support and peer support for sharing knowledge have accumulated higher agreement

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Observational Study

- Focused on the organizational structures (management hierarchies, attribution and validation of knowledge, practices and so forth) in place, enabling or facilitating the diffusion of knowledge
- Our preliminary conclusions from this survey are as follow,
  - Knowledge sharing is encouraged
  - Innovation is encouraged either through collective or individual effort (s)
  - Facilitating knowledge sharing is possible through availability of knowledge maps and communication channels between multi disciplinary teams for specialist areas, which SSTL seems to lack.
- The above results have encouraged us to explore how a text repository will facilitate knowledge diffusion

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Data-driven Case Study

Organization of Corpus

- Sub functional areas within specialist domain of satellite engineering/technology

  - SSTL/SSC, > 1M terms

  - Swedish Space Corp "Satellite Technology news/events" 1995-2004 corpus > 900K terms

  - NASA/BNSC/BSI TC37 (Space systems terminology) select sets of documents apx. 700K terms

Knowledge Repository

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Data-driven Case Study

Organization of Corpus

- 80 SSTL / Surrey Space Centre R&D selected publications
- 206 publications listing, SSTL / Surrey Space Centre
- Select set of PHD thesis listing and abstracts, SSTL / Surrey Space Centre
- Swedish Space Corp, Satellite Technology News, 1997-2005
- BSI document (British Standard Institute), EN 13701:2001, British and European Standard, "Space Technology Terminology". UK Participation: Technical Committee ACE/68, "Space systems and operations"
- BMP, Best Manufacturing Practice Database, encompasses issues about satellite technology and development. A partnership among the US Office of Naval Research's BMP Program, the Department of Commerce's Bureau of Industry and Security, and the University of Maryland's Engineering Research Centre.

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Data-driven Case Study

Ranking of select "weird" words from PhD theses corpora

Rank	Term	Rank	Term
28	multicarrier	31	narrowband
29	magnetorquing	31	groundstation
30	multicast	31	multipath
30	demultiplexer	31	coders
31	multiaccess	31	retransmission
31	wideband	31	demodulators
31	demultiplexing	31	baseband
31	demodulator	31	transmultiplexers
31	intermodulation		

Process-specific

Technology-specific

Ranking of select "weird" words from Swedish Space Corp corpora

Rank	Term	Rank	Term
329	spaceflight	437	mesosphere
373	suborbital	437	thermosphere
396	microsatellite	437	microprobes
399	spacewalk	437	photoreconnaissance
409	spacebus	437	nanosatellites
413	geosynchronous	437	monopropellant
417	minisatellite	438	magnetospheric
418	microsatellites	438	bipropellant
420	spaceflights	438	micrometeorite
421	reconnaisance	438	ionospheric
426	minisatellites	439	microspacecraft
427	hypersonic	439	commercialising
431	nanosatellite	439	hyperspectral
434	actuator	439	multiscale
435	spectrograph	439	photometry
436	deployable	439	interferometry
436	downlink		

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Data-driven Case Study

Ranking of select proper names for authors mentioned within listing of **SSTL/SSC *Satellite Engineering* research**

Rank	Proper Names	Rank	Proper Names
1	**evans bg**	**11**	**hodgart ms**
2	**tafazolli r**	13	hashida y
3	otung ie	13	sammut aj
4	mahmoud ms	**13**	**da silva curiel ra**
5	**sweeting mn**	13	atkinson ia
7	**cruickshank hs**	**13**	**underwood ci**
7	**ward jw**	13	coakley fp

Ranking of select proper names for authors mentioned within *listing of **Electronic and Electrical Engineering research***

Rank	Proper Names	Rank	Proper Names
1	sealy bj	15	pavlou g
2	gwilliam rm	16	knights ap
3	**evans bg**	24	kirkby kj
4	**tafazolli r**	28	**underwood ci**
5	kittler jv	29	palmer pl
6	silva srp	36	**cruickshank hs**
7	hemment plf	38	evans agr
8	homewood kp	44	ward jw
9	webb rp	46	otung ie
13	**sweeting mn**	55	**hashida y**
14	weiss bl	57	**da silva curiel ra**

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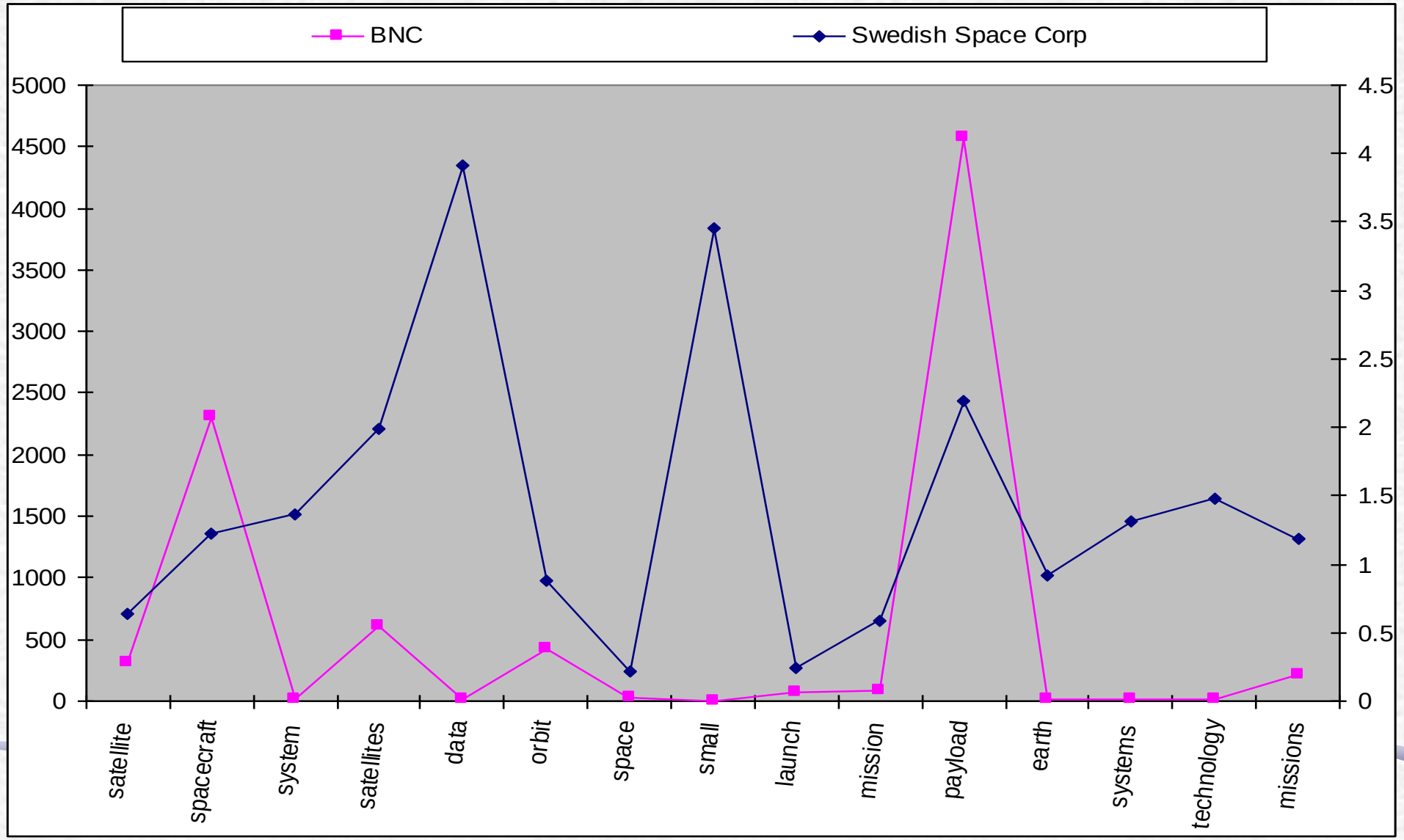
Data-driven Case Study

Select shared terms between SSTL/Surrey Space Centre corpus and Swedish Space Corp corpus



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Data-driven Case Study

The United Nations Standard Products and Services Code (UNSPSC®) – an ontology on satellites

unspsc®

Satellites

- Communication satellites
- Weather satellites
- Military satellites
- Scientific or research satellites
- Navigation satellites
- Geostationary satellites
- Low earth orbit satellites
- Sun synchronous orbit satellites
- Geosynchronous satellites

An Example XML DTD to constitute an ontology for a "Small Satellite" domain – for the research in progress

```
<Object Name= "LEO Satellites">
    <Object Name= "nanosatellites" />
    <Object Name= "microsatellites" />
    <Object Name= "minisatellites" />
</Object>
```

Research Evaluation

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- Validation by and impact factor from expert user / organization through Field Project

- Attempt to establish research links between observational and historical studies

- Applicability (ies) of *knowledge conversion model* (Nonaka *et al*, 1995) in a SME

- Comparison w.r.t research within computer mediated knowledge management

- In each of the four *knowledge conversion phases,* a community of practice appears to have a specific knowledge diffusion process, thus to prefer certain lexical items, a.k.a. *lexical signature*

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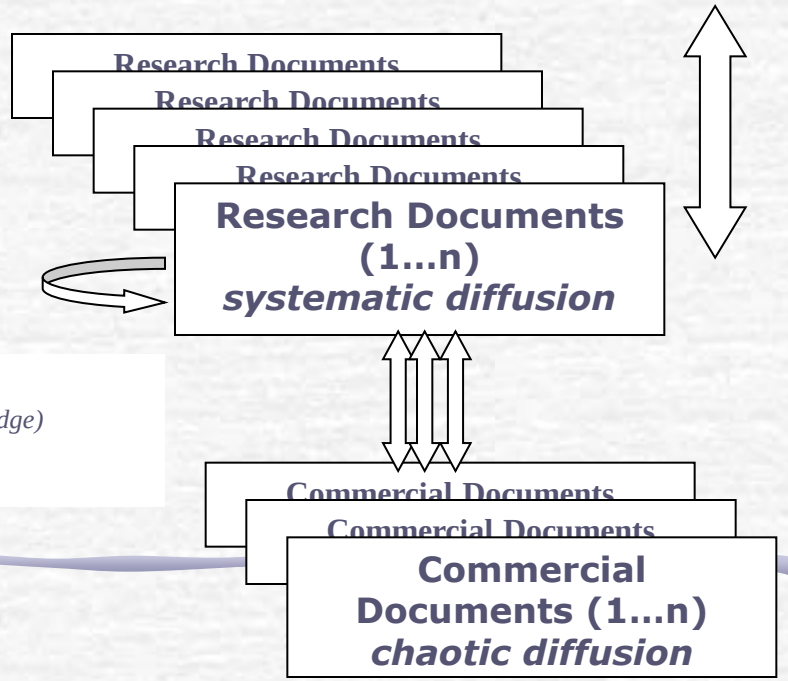
Research Evaluation

- Our analysis shows that research papers and commercial documents can be distinguished somewhat on the basis of single word and compound terms that were generated automatically

- Domain specific terms show the potential for identifying cross-over points in the diffusion of knowledge from the research arena to commercial applications of the domain

Knowledge diffusion through the *knowledge conversion model (Nonaka et al, 1995)*



Research Evaluation

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- Observational study laid the framework for the conduct of our research
    - Focused on examining knowledge flow, and corresponding practices and information technology support in place
- Results from the observational study have indicated that knowledge bottlenecks may exist, in particular were technological support could be needed

- The above has led us to examine how text-based knowledge diffusion may take place

- Model To support manage the growth and diffusion of knowledge within a growing organization

Current Research & Outlook

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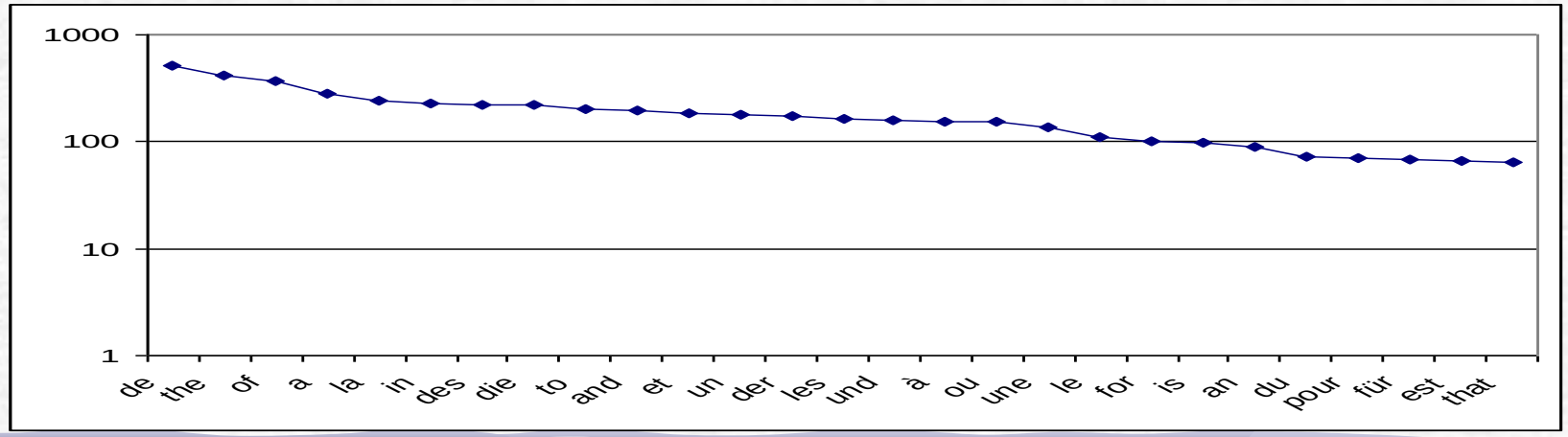
- (Multi lingual) **Diffusion of Knowledge**
  - Between individuals/communities (eWOM & social media on high tech industry)
  - Across domains (Specialist Ontologies)
  - Between organizations (Standards and Partnerships)
- Knowledge diffusion from commercial organization to different levels of a higher education institution (i.e. knowledge conversion from commercial documents to research documents)



Frequency behaviour of multilingual closed class words within "Space Technology Standard"

Concluding Remarks

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- A knowledge management solution must address both tacit and explicit knowledge
- A bimodal (observational and data-driven) research study was conduced
- Text-based knowledge diffusion may be the solution to alleviating knowledge bottlenecks
  - Supported by *knowledge engineers*
- Dissemination of *(best/recommended…) practice* may facilitate the diffusion of knowledge
- Repository based tools should try and support most phases of knowledge lifecycle (i.e. conception/creation/storage/dissemination/maturity/death-recycle)