UCL

Centre for Space Medicine

2001 a space odyssey set design

VULCAN:
Voice and text content analysis to establish crew well-being

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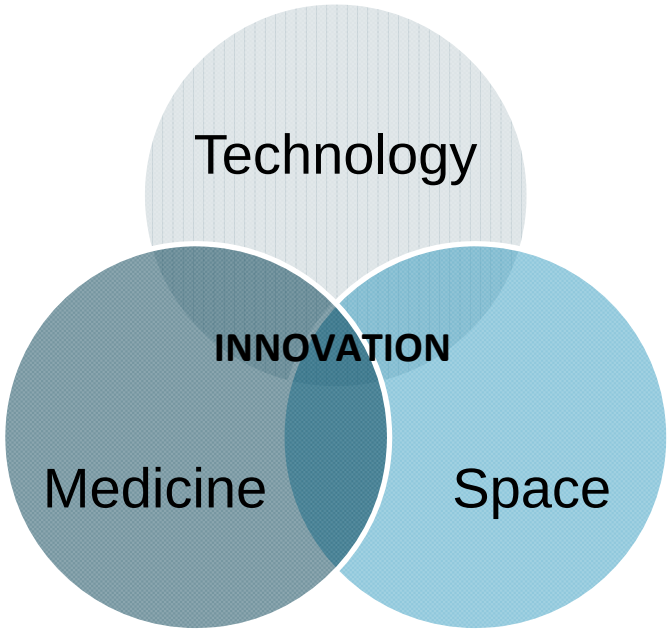
SPACE TESTS OUR LIMITS & POTENTIAL

- **SPACE is A LABORATORY expands our understanding of the human condition & helps to develop technology to facilitate exploration missions, lifestyle & healthcare on Earth**

- **SPACE – very controlled environment where we can gain insight into human condition**



OUR Team is GLOBAL

Applied Science & Techniques & Technology

Innovation & Cross-disciplinary & Cross-domains

Industry

Space Agencies

Collaborators

UCL

THE UNIVERSITY of ADELAIDE

BioTRIZ INNOVATION STRATEGIES
Troubleshooters by nature

BIO TRIZ

STRACON GyM

EstrellaSat
The World is Mobile

SATEX

Satellite Communications
CONSULTANCY SERVICES

WOMBAT

UK SPACE AGENCY

esa

NASA

ROSCOSMOS

ИМБП

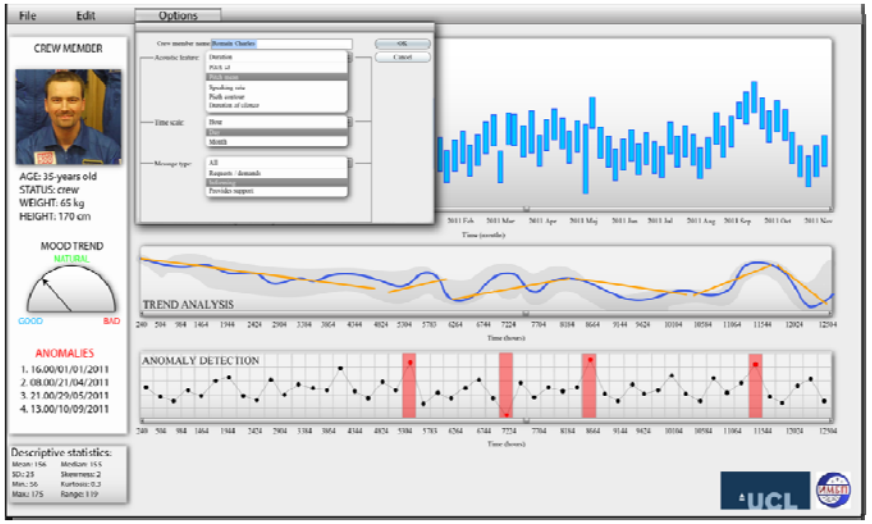
NATIONAL SPACE BIOMEDICAL RESEARCH INSTITUTE
NSBRI

VULCAN – Voice & Content Longitudinal Analysis

Assist in understanding group climate

- **Non-invasive & non-intrusive**
- **Preserving privacy**
- **Allowing multi-language mixture in messages**

Assist in adjusting the communication style by the Mission Control Centre



Originated in ESA EPSILON project

- **20 experts extreme environments**
- **Over 2000 challenges identifies**
- **36 categories of challenges**
- **24 high priority tools identified**
  - **VULCAN is one of 24**

CONTENT ANALYSIS

VULCAN – Voice & Content Longitudinal Analysis

MARS500

Text Content Analysis

CURRENT WORK:

- **IBMP runs ISS experiment “Content”**
- **Analysed Daily Progress Conferences & MCC–ISS daily dialogues**
- **UCL and BioTRIZ team analysed MARS500 data**
- **Compared MARS500 & found – thesaurus differs**

OPERATIONAL WORK:

- **Adapt thesaurus for each mission**
- **Mission goals & challenges may vary**

Text content analysis: conditions and challenges

- Privacy
- Non-invasive & non-intrusive way to study group climate
- Multi-language mixture in a message
- Thesaurus needs tuning due to individual vocabulary & professional jargon
- Identifies criticality of the issue based on content analysis
- Fast evolution of language in new environment, “space” language

CONTENT ANALYSIS

Content analysis is a method for grouping of communication parameters into the limited number of categories with the help of preliminary defined coding rules

(Berelson, 1971; Krippendorff, 1980;
Weber, 1990, Neuendorf, 2002)

Text Content Analysis: Our Solutions

- Private
  - we need to understand the context of the message without understanding its meaning; use word-labels
- Non-invasive / non-intrusive
  - way to study group climate - texts/messages are analysed in the background
- Multi-lingual
  - thesaurus - only important words (labels) are registered, grammar free, so multi-language thesaurus starts making sense.
- Individual vocabulary and professional jargon can be included as synonyms to the words-labels.
- Evolution of language in a new environment, “Space” language
  - VULCAN tool can be adaptable to new words. When unknown context is detected, crew members can label the words for the new context and name this context accordingly.

Vectors of Well-being: defining the contexts

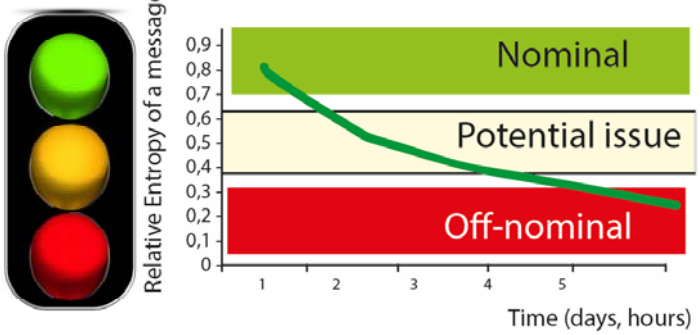
	Individual	Crew	External conditions/Technology	MCC
Individual	Cognitive perfprmance. Fatigue/Performance	Leadership Communication	Problem solving (frustration, uncertainty)	Fatigue/Performance Emotional stability
Crew		Group climate	Communication Problem solving	Communication. Crew independence
External conditions/Technology			Adaptation to new environment (frustration, uncertainty)	Mission schedule
Mission Control				Communication

Well-being: parameters describing contexts

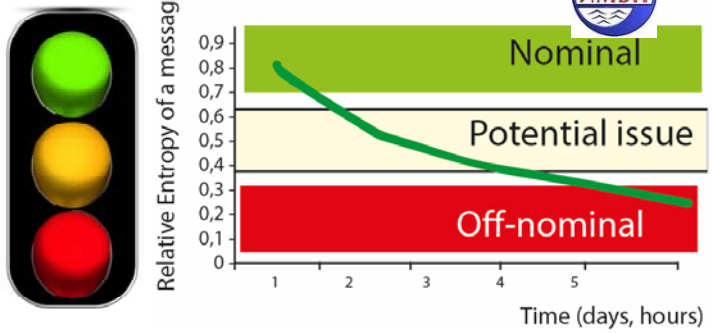
Contexts	Parameters of well-being to measure MARS	Content analysis: Parameters to detect. "traffic light system"		
		green	yellow	red
Communication issues	Expression of emotion Expression of self-control Repetition	Informing	Expression of self-control Repetition	Strong expression of emotion
Fatigue	Search for support, time, sleep, avoidance	Provides support	Search for support Time pressure	Sleep, avoidance
Group climate and leadership issues	Emotions Disobedience, Humor, Initiative, Responsibility transfer, Self-initiated actions (can also be against the command or advice), Refuse to proceed (rational confrontation)	Humor Positive emotions	Responsibility transfer Initiative	Disobedience, Disagreement, Self-initiated actions (can also be against the command or advice), Refuse to proceed Rational confrontation
Cognitive performance	Obedience Refuse to proceed Irrational confrontation Repetition	Obedience	Repetition Refuse to proceed Mistrust	Irrational confrontation
Technical issues	Requests / demands Repeated requests Search for support	Requests / demands Informing	Repeated requests	Search for support Self-control

Well-being parameters monitoring

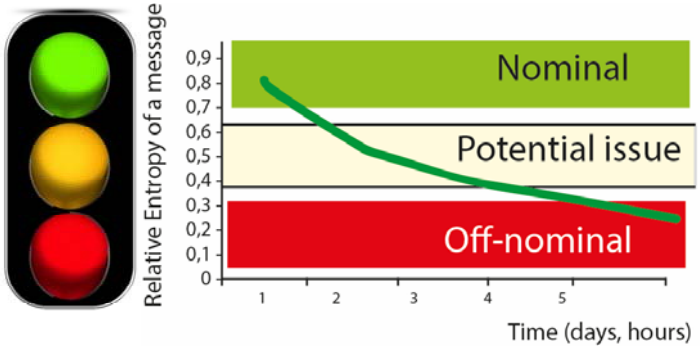
Communication



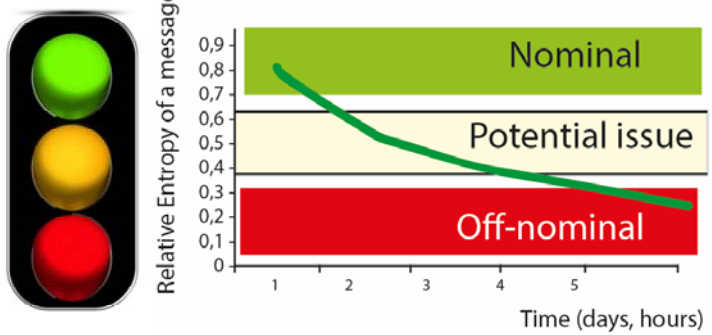
Group climate



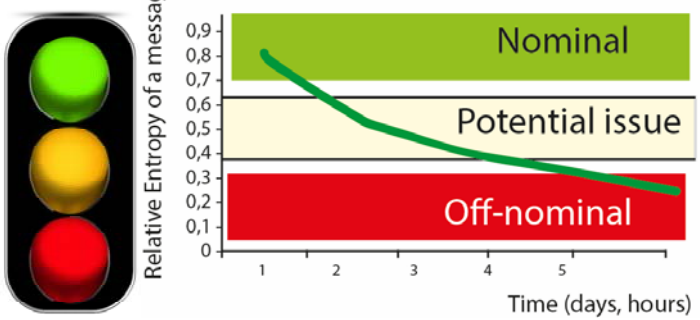
Cognitive performance



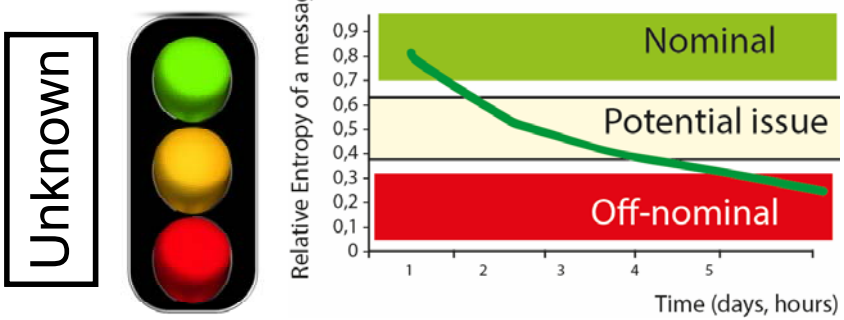
Technical issues



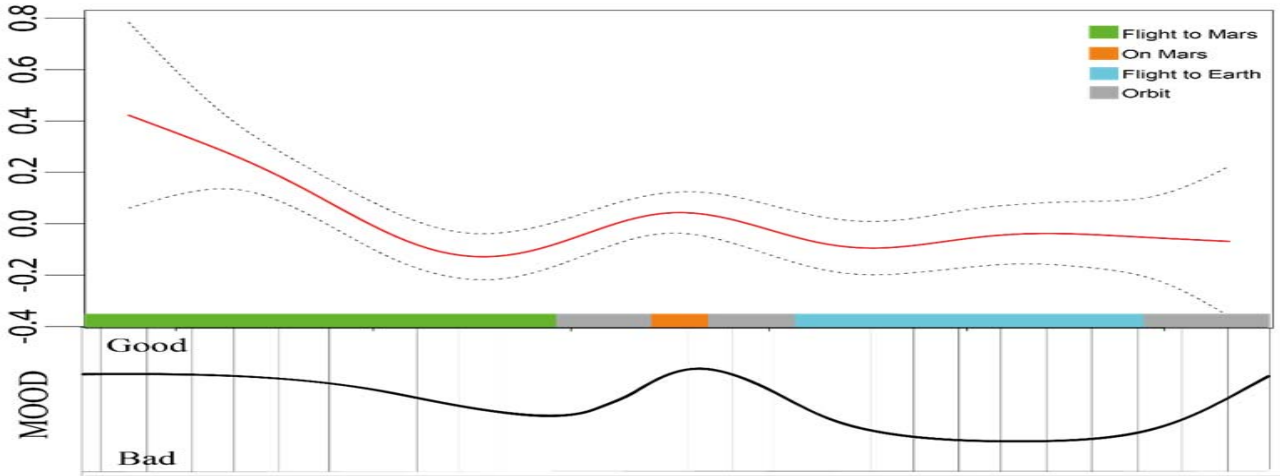
Fatigue



Unknown



Three sets of results: voice analysis of combined voice features (above), the hypothesised Mood Index (middle) and content analysis (below).



KEY:

Communication

Fatigue

Group climate

Technical Communication delay . . .

Content analysis: achievements & planning activities

Phase 1

- Developed mathematical algorithm
- Created programme in "R" for text analysis
- Analysed texts that describe nominal situation
- Analysed texts that describe off-nominal situation
- Adjusted word ranking system

Phase 2

- Validate the algorithm on the texts that describe nominal and off-nominal situation on real space flight
- Develop the software prototype
- Update multi-language word labels
- Validate the prototype on multi-language messages

Phase 3

- Test of the software prototype on ISS missions

(see separate presentation)

VOICE ANALYSIS

NEXT FOR VULCAN

iVOICE

integrated VOIce analysis of satellite Communications Embedded in time & safety-critical environment

iVOICE Way Ahead: potential use / pitch points

- iVOICE is being trialled accepted in the mining, it will be accepted in other industries
  - e.g. Sleep science : 17 hours awake is equivalent to a blood alcohol content of 0.05
  - If your sleepless hours add to 21, your ‘blood alcohol’ content can reach 0.08
  - Result = decline in performance
    - slower reaction times
    - failure to respond to changes
    - inability to concentrate
    - inability to make reasonable judgments

- iVOICE CAN PREDICT DANGEROUS LEVELS OF FATIGUE

iVOICE – Applications – Predicting Fatigue

- discriminates ~80% speaker independent, ~90% speaker dependent

For Operators & Control Centres

In

- **Transport**
- **Aviation – pilots - ATC**
- **Maritime and Offshore**
- **Medical – surgeons**

VULCAN Phase 2 & 3

- **Duration:**
  - **30 months (Phase 2) – GSTP 6 Element 1**
  - **12 months (Phase 3) – GSTP 6 Element 2**

- **Deliverables:**
  - **Software Voice & Content Analysis prototype**

- **TRL:**
  - **Current TRL: 3**
  - **Target TRL: 6 (end of Phase 3)**

- **Target Application:**
  - **Exploration missions with tests on ISS experiment**

VULCAN Phase 2 & 3: Funding

- VULCAN Phase 2
  - PROGRAMME under GSTP Element 1
  - DURATION: 30 months
  - BUDGET: 1,196,874 EURO (per year 478,749)

- On successful completion of Phase 2 to progress to...

- VULCAN Phase 3
  - PROGRAMME: GSTP Element 2
  - DURATION: 18 months
  - BUDGET: 695,430 EURO (per year 463,620)

VULCAN Phase 2

- Generation:
  - VULCAN voice & content software
  - User Interface (UI)

- Test equipment & operational setup at IBMP ISS-MCC environment equivalent:
  - 2-weeks with sleep deprivation (A)
  - 2-weeks with sleep deprivation (B)
  - 4-months with sleep deprivation (C)

- Continues update of VULCAN algorithms based on:
  - Ground testing results of A, B & C
  - Latest voice & content data from ISS
  - Increasing number of crews in analysed corpus throughout phases 2 & 3
  - Data variability between every crew & missions.

As a result the algorithms will continuously improve

VULCAN PHASE 2: Tasks

- Testing of the crew communication data analysis algorithm (voice and content) between the MCC and the isolation chamber study simulating ISS environment.
- Crew communication (voice and content) data collection during short/long-term Space Flight environment simulation in the specialised chambers at the IBMP.
- Testing software for voice and content analysis in preparation for installation on-board ISS.
- Testing of software and equipment setup for voice and content analysis in 2-week space simulation environment (including noise) in hermetic chambers to detect performance difficulties and problems in communication and data capture.
- Transfer from voice to text, adjusting the beta-version of software for analysis of voice and text.
- On-Earth reliability approbation of the software and hardware (for voice and content data) dedicated to be installed on ISS board – during the 4-months space simulation conditions including noise level.
- Official testing on Earth of the software and hardware (for voice and content data) dedicated to be installed on ISS board in Phase 3. Testing includes approbation of performance compliance.

DELIVERABLES: Certificate of approbation of the soft and hardware in space simulation conditions including noise level.

PERSONNEL: 7 UCL, 3 IBMP people

VULCAN Phase 3

- Installation of the final software on ISS & MCC:
  - For voice analysis
  - For content analysis
- Test in a real operation space flight environment
- Update of any issues detected in the testing phase
- Release of the final software for operation

VULCAN Phase 3: Tasks

- Official testing on board ISS of the content and voice analysis.
- Testing of software's compatibility with on-board computers & software already installed.
- Obtaining first voice and content data from the ISS
- Test of the software for content analysis (to detect the level of efficiency of communication within the crew) onboard
- Test of the software for voice analysis (to detect the level of efficiency of communication within the crew) at MCC
- Official Protocol for space crew psychological monitoring base on content and voice analysis of crew communication with MCC.

DELIVERABLE:

- Software for in-flight monitoring of crew cohesion and psychological state, monitoring of interaction with MCC.
- Certificate of approbation of the soft and hardware in space simulation conditions including noise level.

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ESA VULCAN Project

QUESTIONS & COMMENTS