Canada Border Services Agency | Agence des services frontaliers du Canada

Video Analytics: Technology Maturity, Deployment Challenges, and Roadmap

VT4NS 2010

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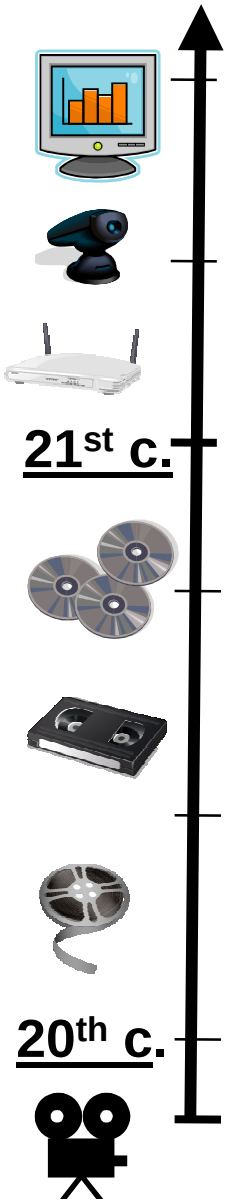
Outline

1. What is Video Analytics (VA)
2. Technology Maturity (adaptation from DoD):
   - Technology Readiness Level: TRL(VA) = 1, …, 6
   - Other Technology Maturity criteria
3. VA deployment challenges
4. Three-Phase Roadmap for VA deployment
   - Our 1st objective - to test TRL (VA)
   - Our 2nd objective - to raise TRL (VA) to 7 & 8

What is Video Analytics?



- **Video Analytics (aka Intelligent Video, Smart Camera, Video Recognition): Computational Analysis of Video Data that deals with Automated Extraction of Intelligence from Video.**

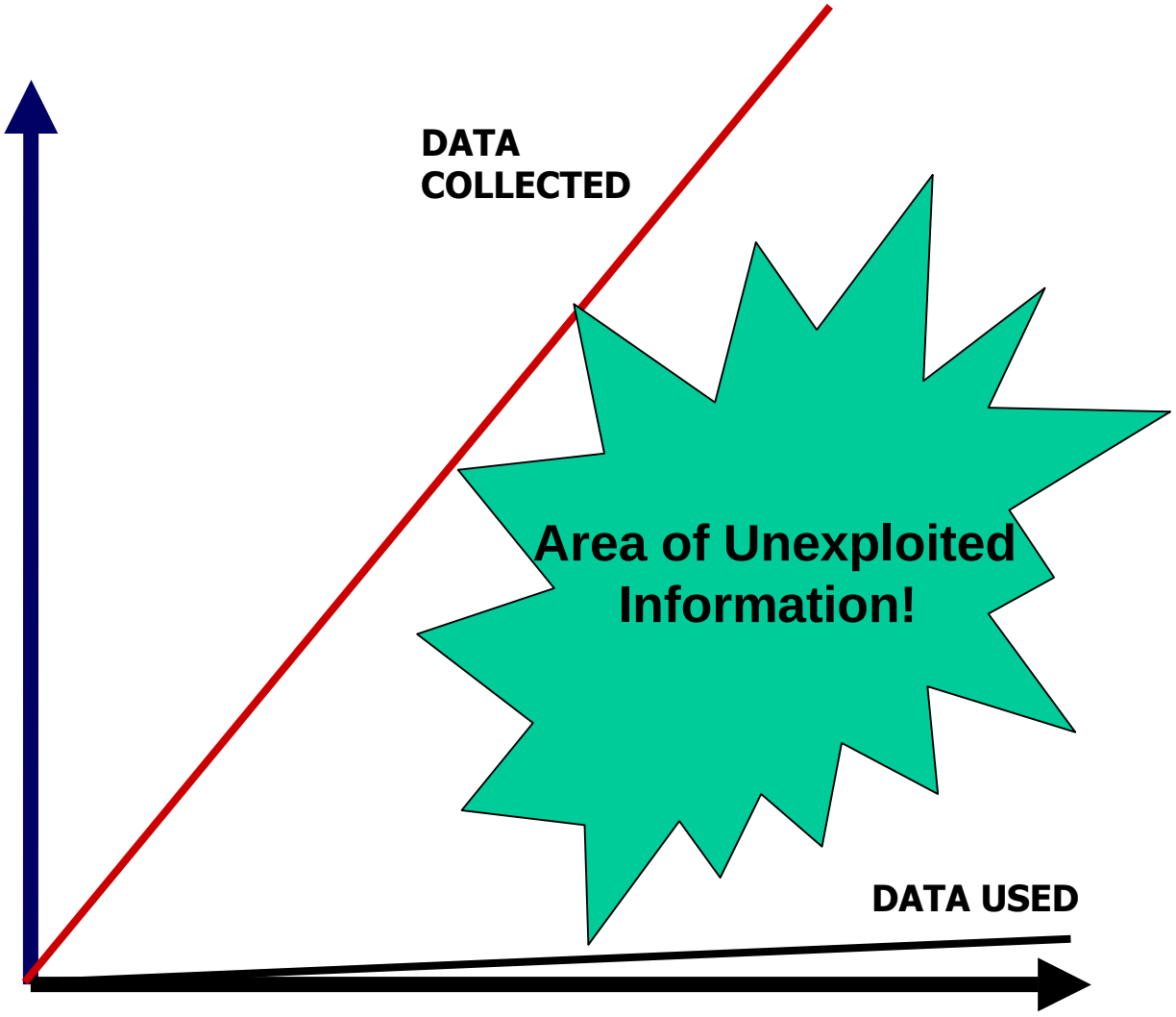
- **High resolutions**
- **IP cameras**
- **Digital**
- **Analog**

←Animated image example:
The entire 17:00- 24:00 activity is summarized into a few annotated snapshots

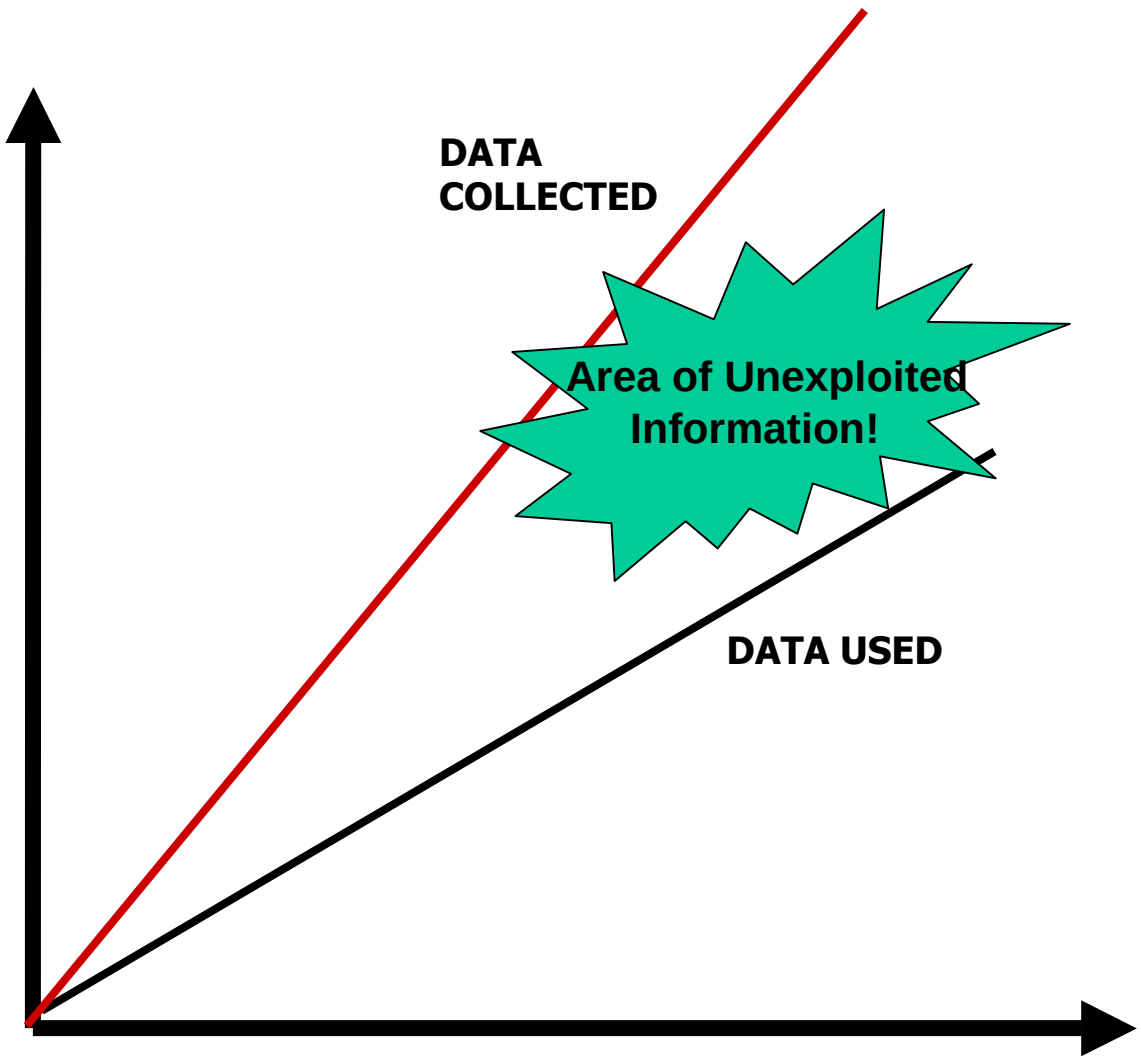
(with NRC's ACE Surveillance™).

- Video Technology (VT) of the 1990's was primarily concerned with video capture (Cameras and Recorders)
- Today, VT is Video Capture + Video Analytics

Without Video Analytics - as it is now



With Video Analytics - what we can do



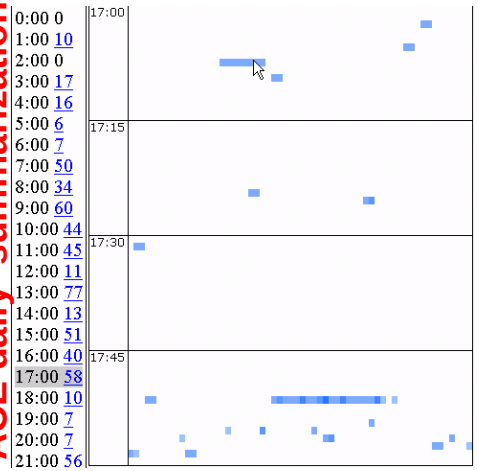
ACE Surveillance™ VA Pilot (2006-2008) [Gorodnichy, NATO-2008]

Camera / setup

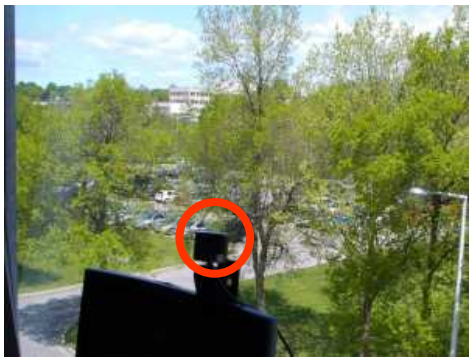
Annotated CES

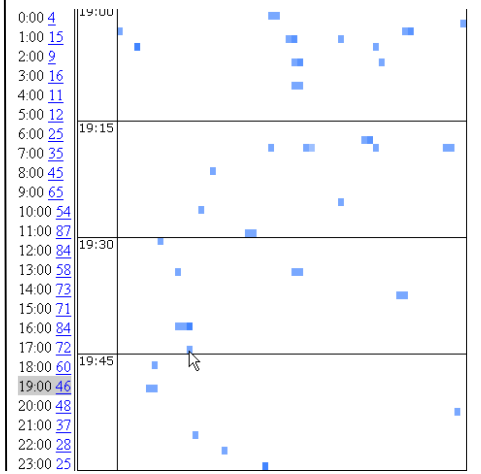
ACE daily summarization

Outdoor, wireless, eye-level

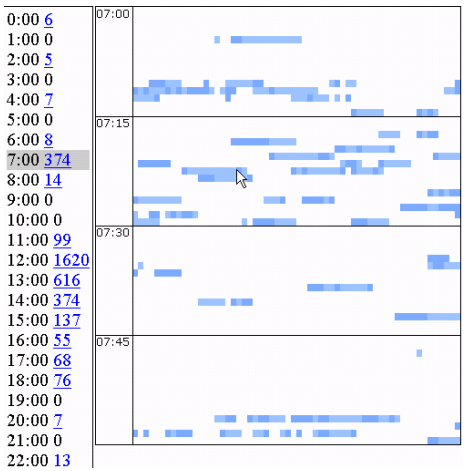


Outdoor, webcam, overview

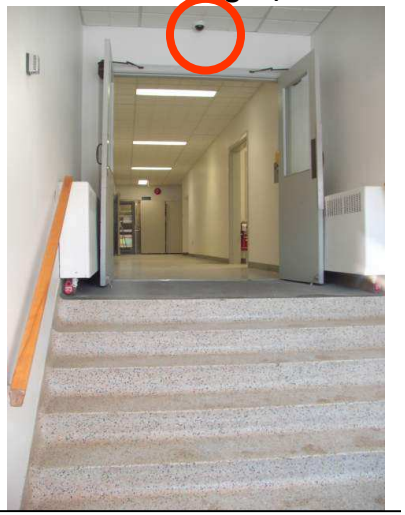


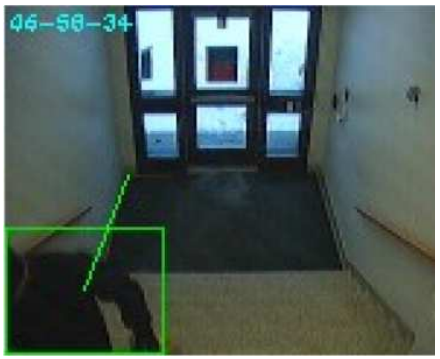


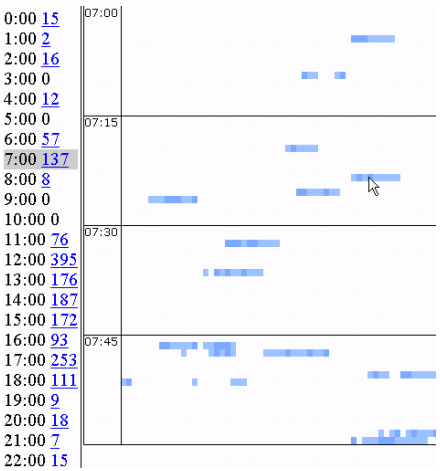
Indoor with sunlight, CCTV



Indoor w/o sunlight, CCTV







Video Technology components / cost

1. Video Data Capture
2. Transfer
3. Storage
4. Protection and security

Technologically solved

- cameras
- encodes, decoders
- transmitters and receivers
- routers and multicast switches
- network video recorders
- storage media

5. Integration with other sensors / software
   - Motion, heat sensor, audio, Video Analytics
6. Video data management
   - Indexing, visualization, retrieval of data
   - Data = video + associated Meta-data (Annotations) obtained with Video Analytics
7. Video analytics for automation and filtering:
   - Real-time event detection / recognition
   - Analysis of archived video data

Being solved – requires exploring, evaluation, tuning (inc. RFI, Pilots)

Total cost = Hardware + Software/Testing/Tuning

Video Analytics expertise minimizes the cost of both components.

+ Operational Cost/Value

What Video Analytics is NOT ?

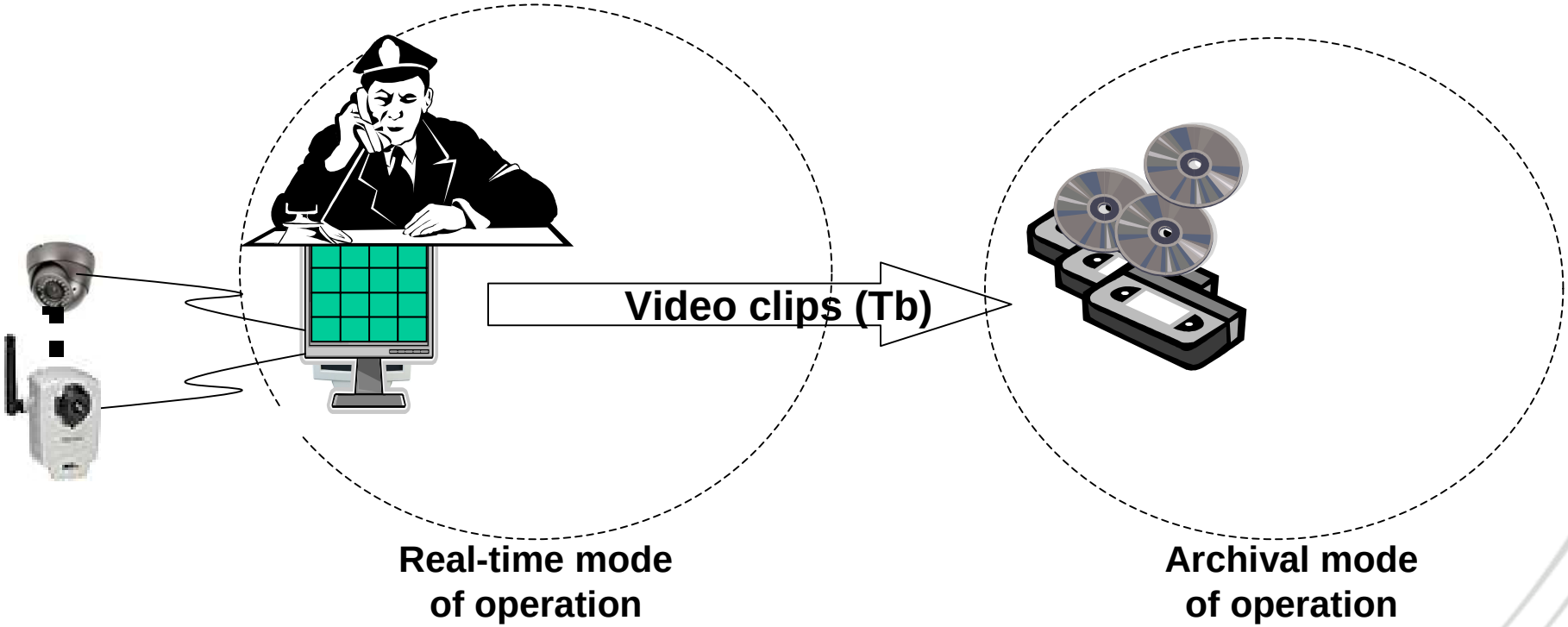
- "Brightness change detection" marketed by industry as "motion-detection", which is NOT.
- NOT a "Magic bullet":
  - Just as with ANY image recognition (inc. Biometrics), there will be "False Hits" and "False Misses".

  ➔However, their Rates can be minimized to acceptable for operational needs – by evaluation and customization.
- NO "one size fit all" solution (esp. in Non-cooperative scenarios)
  - Different VA codes required for each setup, environment, task.

  ➔However, experts may use the same library to write these codes.
- "High resolution / quality" do NOT assume "high intelligence".
- It is NOT expensive with proper (unique) skills and planning.
  - In fact, it (significantly) reduces the entire cost operation, though the optimized equipment build-up and efficient data analysis.

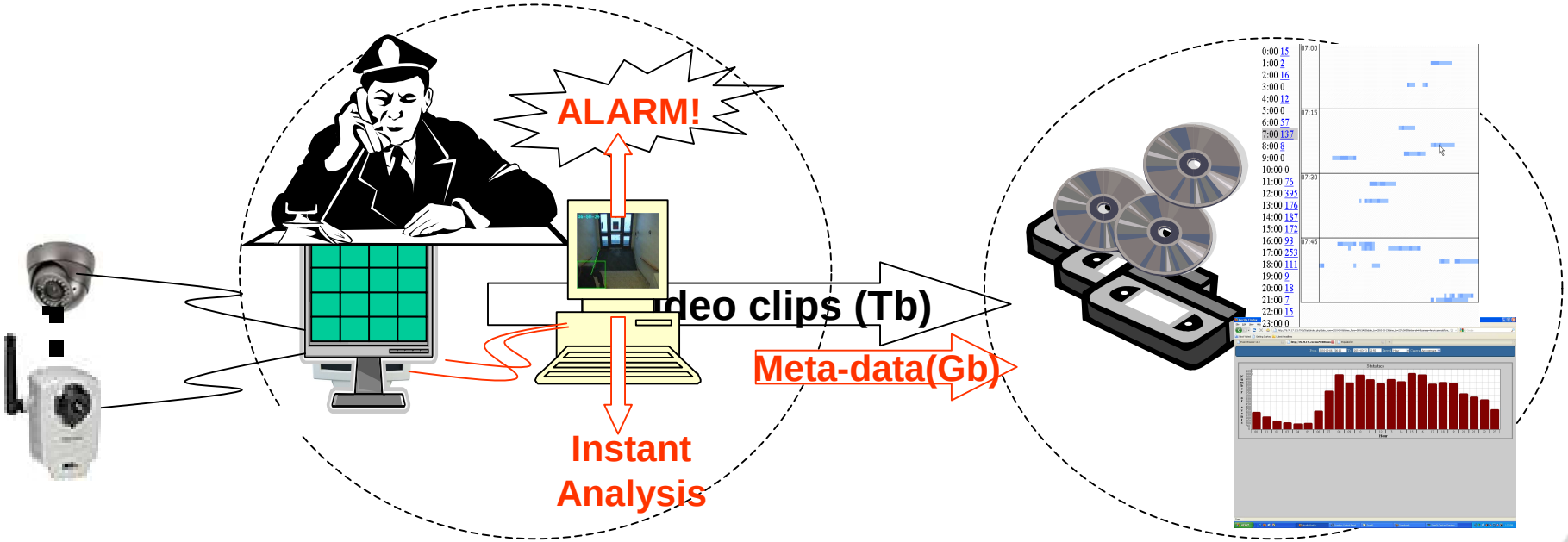
Monitoring Tasks Performed by Human (Status quo)

Two modes: a) real-time monitoring, b) post-event analysis



Monitoring Tasks Performed by Human & Software

Two modes: a) real-time monitoring, b) post-event analysis



Real-time mode of operation

Capture filters / modules

Archival mode of operation

Retrieval modules / software

Main condition - Open Architecture:

To be able to tap into (video signal) input and (data) output.

(Critical) analysis of VA Market and readiness

Main question:

What is possible,

what is not,

and

how to distinguish one from the other ?...

Insider's view – how industry does it

- There are >5000 companies registered in Canada doing business in "Surveillance" [NUANS Search Results in 2008]
- Anyone who does Surveillance" can add "Intelligent" or "Smart" just by doing "pixel brightness comparison".
- Some go further
  - by creating many "heuristics"
    - no University knowledge required,
    - tuned for one setting / does not work for another
  - use Public domain codes, of which there many
    - OCR, Face Detection, Some Face Recognition,
    - Many low-level image processing libraries (edge detection, colour segmentation, motion/optical flow computation)
- However, very few go further – hire MSc/PhD in Computer Vision / Pattern Recognition to do higher-level (semantic) processing of images –which is still one the most challenging research areas (eg See CRV conference)
  - (eg. http://www.computerrobotvision.org/tutorial_day.html)
- As a result, many companies list *many* VA tasks they "can" do.

VA tasks companies “can” do:

From www.i3dvr.ca, www.intelliview.ca www.visualcortek.com www.miovision.com, www.marchnetworks.com www.ioimage.com www.nice.com www.indigovision.com www.iomniscient.com, www.objectvideo.com (and many more):

- Human / Object Recognition and Tracking
- Object Classification
- People Counts
- Vehicle recognition
- People recognition / Face recognition
- Unattended Baggage Detection
- Object Removal Detection
- Loitering Detection
- Tail-gating
- [Waiting] Line Control, Crowd management
- Special Attribute Detection
- Advanced Behaviour Analysis
- Slip and Fall Detection
- Intrusion Detection / Virtual Tripwire
- Autonomous PTZ Tracking
- Stopped Vehicle Detection
- Camera Tampering Detection
- Congestion detection
- Counter Flow
- Automatic Licence Plate Recognition
- Object Alteration Detection
- Audio and Sound Classification
- Face Detection / Face Tracking
- Graffiti / Vandalism detection
- Highway (vehicle) count

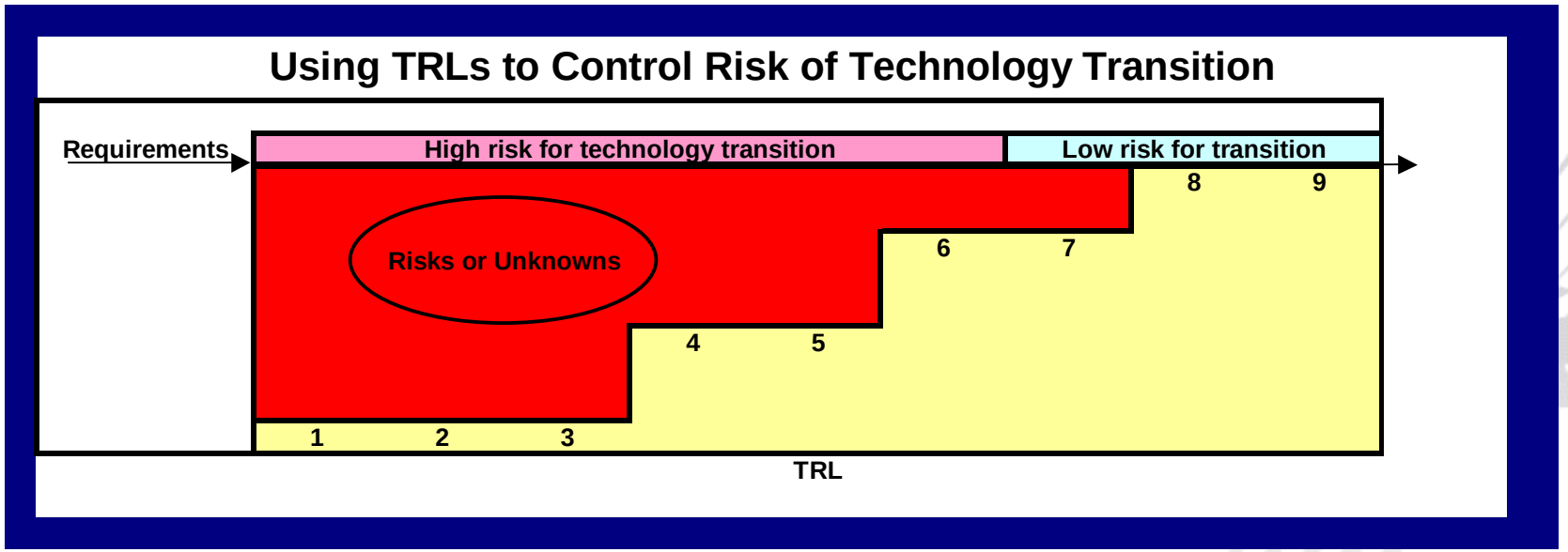
Insider's view – how Academia does it

- VA is one of the least resolved and most researched areas:
  - Every year, >5 major conferences, >1000 papers published
  - Every year, practically every university has 2-10 MSc/PhD students working on un-resolved problems in content (semantics) retrieval from images/video
- Some VA tasks are indeed now possible,
  - But all have limitations
- Most of reported VA solution have never been tried in live (24/7) operational environments

Technology Maturity 101 (from DoD, NASA)

Main: Technology Readiness Level (TRL)

- intensively used by (DoD, NASA, DHS, DNI)
  - Provides aCommon Understanding of S&T Exit Criteria
  - A Risk Management Tool & Allows to estimate Cost/Investment required
- However, it is only one dimension of Techn. Maturity.



Other Technology maturity criteria:

Adopted from Air Force Research Lab:

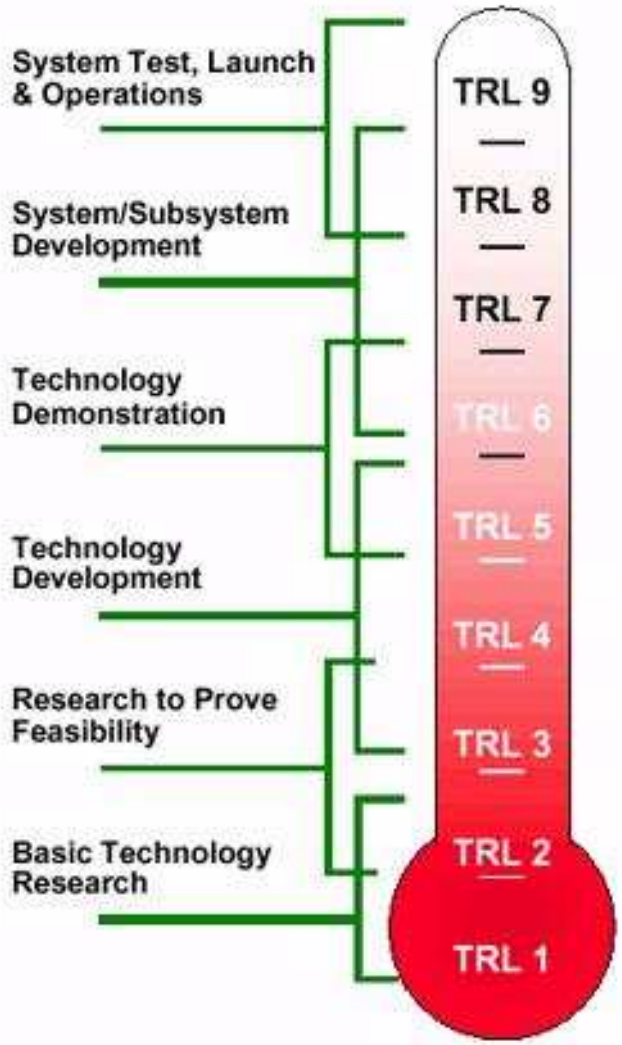
- Producibility – Manufacturing Readiness
- Readiness to Receive (If Goal Is Transition from Technology Developer and Technology Receiver
- Practice Based Technology Maturity (Emphasis on Community of Users) – User Readiness
- Program Readiness (program needs and constraints)

+ (added by VSB)

- Required In-house R&D capacity: R&D Readiness
  - Customization & tuning required

Technology Readiness Level (Source: DOD, 2006)

1. Basic principles observed and reported.
2. Technology concept / application formulated
3. Analytical and experimental critical function - characteristic proof of concept.
4. Component validation in laboratory environment.
5. Component validation in relevant environment.
6. System prototype demonstration in relevant environment.
7. System prototype demonstration in operational environment.
8. Actual system completed and 'flight qualified' through test and demonstration.
9. Actual system 'flight proven' through successful mission operations (over 30)



TRL (most VA) = 3-6 !
TRL(ACE Surveillance) = ~7
TRL (VAP) = ~7

Doing VA TRL assessment

- DNI VACE (2005-2008) –selected successful VA projects
- Several Video datasets developed to test VA
  - NIST TREKVID – the most comprehensive
  - CLEAR (used by VACE)
  - From Home Office (UK)

However: <u>They allow to test / achieve TRL up to 6 only!</u>
(ie. prototype is successful in <u>relevant environment</u>)

Besides: the participant are all from Academia (not from Industry!)

So how will you know the TRL of the VA that you need ?..

Video Analytics Technology Readiness

Traditionally performed by Humans, many of these Monitoring Tasks can now be facilitates with VA software

TYPE 1: Real-time monitoring tasks	Customization, testing req.-d	Technical readiness	Program readiness
1* - "Face extraction/tagging"	Little	5	4: Ready for Pilot
2* - "Wrong direction detection (Run-away alarm)"	Little	5	4: Ready for Pilot
3 - "Loitering alarm"	Major	4	4
4 - "Object-left behind or abundant object alarm"	Major	4	4
5 - "Tripwire (trespassing) alarm"	Little	5	4: Ready RFP
6 - Other events (door opening, car parking etc) alarm	Major	4	4
General Tracking / Detection of people in multiple streams	-	1	-
TYPE 2: Post-Event (Archival) monitoring tasks			
1 - Summary of detected events & statistics (trends)	Little - Medium	5	4
2 - Searching for a object/person in stored streams	Little - Major	5	4
General Summary / Search in unstructured environment	-	1	-
Special case tasks			
LPR (License Plate Recognition)	None	7	5
Face Recognition	Little-Medium	1-7	1-4

5 – ready, 4 – requires Evaluation only, 3/2– requires further Refining/Exploration, 1 – not yet ready

Main objective of R&D prior to deployment

Our goal with VAP/VAT:

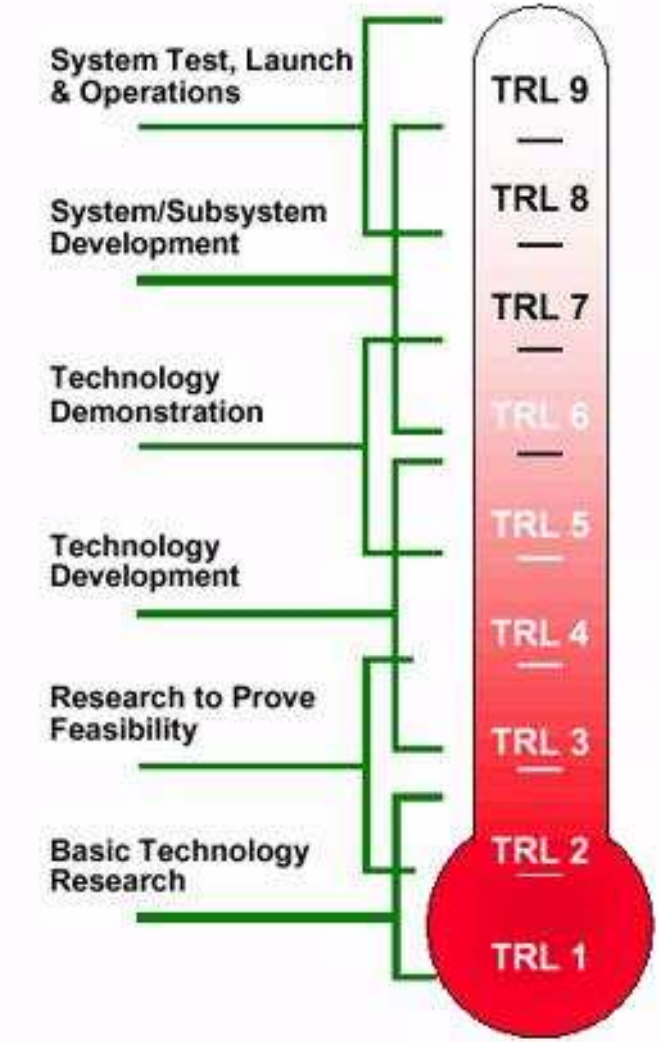
- to test TRL /achieve TRL (VA) =7 (in operational environment)

  and,

- possibly to attain TRL 8 and 9 for some VA technologies

+

- work with Operations/Programs/Industry to examine other dimensions of VA Technology maturity



VA deployment challenges & Road-map

Phase 1 (Foundation): Building Business, Infrastructure foundations; R&D capacity

- From Knowing the Art of Possible (TRL) to Making it Possible
  - Dealing with Stereotypes / Misconceptions
  - Not to over-estimate or under-estimate what VA can do
  - Investigating TRL, risks/capacity to do R&D

Phase 2 (Development): Resolving Technological Challenges

- R&D programming + Knowledge of Operational Tasks
- Dealing with "Closed Architectures"
- Selecting/Building a solution

Phase 3 (Pilots). Testing and deploying the solution in the "field"

- Knowing Clients needs & Educating/Training the Client
- Customizing, stress-testing (in Mock-up and real setups)

Building VA Solution: Technical challenges

1. Different tasks and scenarios require different VA codes to be written, and the customization of the VA codes can be properly done only by a Video Recognition expert. At the same time, VA customization requires strong knowledge of operational tasks as well as constant communication with the involved regions. As a result, a solution coming from outside is often very expensive and in many cases not reliable.
2. IP-cameras contain vendor-specific coding/encoding mechanisms, and getting a video-feed from these cameras requires customization in programming codes specific to each vendor. Furthermore, while some vendors provide functionality to perform direct capture of the video-feed from their cameras through the use of a dedicated SDK (Open Architecture cameras), others do not (Closed Architecture cameras).
3. Selecting a good VA product requires the testing of different products for the purpose of measuring and comparing their performance for a given task. Most agencies cannot afford to perform such testing and have to fully rely on the vendors' claims instead.

These challenges are being resolved by

- Creating CBSA-S&E VSB section
- Developing VAP/VAT technology

… proceed to next presentation