

# History of Wide Area Surveillance work in the visual/IR domain

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# Agenda

- 1 Council for Scientific and Industrial Research
- 2 Close In Surveillance
- 3 Automated Camera Calibration Suite
- 4 Centralised WASS Prototypes
- 5 Rugged Modular IR Enhanced WASS
- 6 From Ocean to Battlefield
- 7 Where we are now
- 8 Future development plans for WASS
- 9 Q & A

# Council for Scientific and Industrial Research

## CSIR

- South African Government national research center.
- Founded in 1945
- Employs  $\pm 3000$  people.
- Research areas:
  - Defence
  - Biomedical
  - Mining
  - Built Environment
  - Natural Resources
  - IT
  - Material Sciences
  - LASER systems

## Defence (DPSS)

- Optronics
- RADAR and Electronic Warfare
- Aeronautics
- Integrated Systems
- Command and Control
- Landward Sciences
- Special Operations

# Council for Scientific and Industrial Research



# Optronic Sensor Systems

- Image processing
- Surveillance
- Camouflage
- IR simulation
- IR counter measures
- Optical design
- Test and evaluation
- Optomechatronics

# The Need for WASS

## Asymmetric Warfare:

- Gorilla warfare
- Vast damage at low cost
- Opponents pose as civilians
- Small wooden craft with low RADAR signature
- Need to monitor immediate area around the ship
- Developed at request of SAN
- USS Cole, Aden Yemen, Nov 2000
- USNS Rappahannock, Jebel Ali, UAE, July 2012



# Why go for an optical solution?

## Humans:

- $\pm 175^\circ$  Field of View (FOV)
- Built in advanced image processing
- Get detail on a small  $2^\circ$  cone
- See what they expect to see
- Fight with boy/girl friends
- Require body/sleep/smoke breaks
- Poor night vision

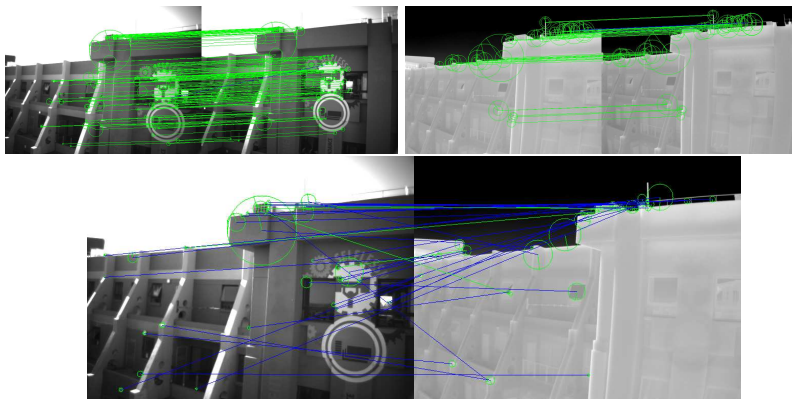
## Cameras:

- Configurable FOV
- Can observe in low light and adverse conditions
- No requirements for sleep, etc
- No built in image processing
- Can store captured images for later retrieval

# How WASS works

- Cameras are geometrically calibrated, including their 6 DOF relative positions
- Camera outputs are photogrammetrically stitched in Real-Time into a seamless panorama
- Images are stabilised for ship motion
- Background modelling is performed, to counter cloud and ocean movement
- Moving targets are identified
- Targets are tracked

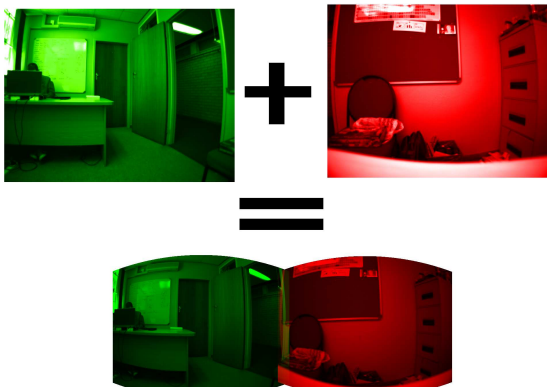
# Feature vs Photogrammetric Stitching



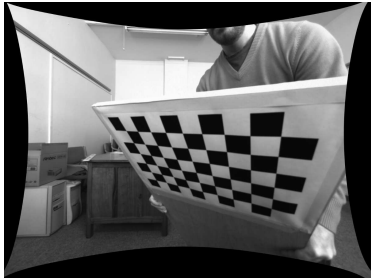


# Why calibrate the cameras?

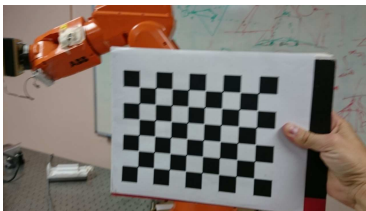
- Allows wide angle lenses to be used.
- Allows any camera with and FOV or spectrum to be used.
- Leads to real-time stitching.
- Allows designation from stitched image.



## Distortion characterisation, according to the Internet



# How about non-visual cameras?



# Automated Camera Calibration Suite

## Desired characteristics

- Automatic
- Repeatable
- Precise and accurate
- Adaptable to different spectra, FOVs and resolutions
- Accept differing camera output formats
- Apparatus is self calibrating

## Required Outputs

- Distorted→Undistorted mapping
- Undistorted→distorted mapping
- Focal Length Determination
- Camera→mount pose
- Mount→reference pose

# ACCS: Overview

## Physical Components

- Robotic arm
- Optical bench
- Kinematic camera mounts
- Swappable energy sources
- Precision mechanical jig
- Pleora<sup>TM</sup>GigE converters
- Computer

## Principals of Operation

- Place camera on mount
- Attach energy source to robot
- Move robot through sequence of discrete points
- Capture energy source image coordinates
- Process coordinates

# Distortion Characterisation



# WASS-60: Proof of Concept

## Overview

- 4 1.3MP Cameras
- 60° by 20° stitched image
- Stitching at 360FPS
- Stitching and background at 100FPS
- Stitching, BG & tracking at  $\pm 25$ FPS
- Field trial at Naval Station Durban in 2008



# WASS-360: Omnidirectional Surveillance

## Overview

- 4 1.3MP cameras & 1 2MP camera
- Large FOV high distortion 4.8mm lenses
- 360° by 60° stitched image
- 3 Week trial in Simonstown
- Deployed on IMT's Sealab research vessel
- Deployment on (docked) SAS Amatola
- Deployed at Paardefontein in May 2013



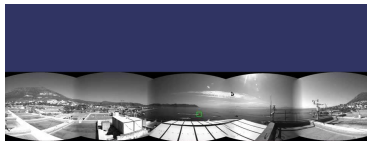


# WASS-360 Highlights

## Milestones

- Omnidirectional panorama
- Sinusoidal stabilisation
- Kalman and Particle filter tracking
- Appearance modelling
- Multi-target tracking
- GIS alignment
- Highlight targets from external RADAR
- Show FOV of turreted systems
- Designate high-zoom cameras and tracking RADARs
- Streaming of stitched image

# WASS-360 Video Clips



# Overview

- 
- WASS-90

# WASSABBI: Moving to 24h capability

## Incorporating SAN Feedback

- Evolution of WASS-90
- First shown at AAD in Sep 2012
- Incorporates LWIR images
- Real time Image fusion
- Improved close range stitching
- Remote power cycling of cameras



# WASSABBI: Improved Near-Field Stitching

Spherical stitch at 1000meters

Only distant building (D) is stitched correctly.  
Water edge (B) diverges.



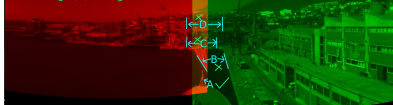
Spherical stitch at 250m

Only buildings at the end of the pier are stitched correctly  
Water edge (B) diverges



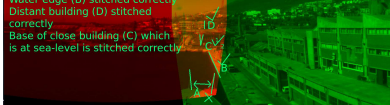
Spherical stitch at 51meters

Only the bow is stitched correctly  
Water edge (B) diverges

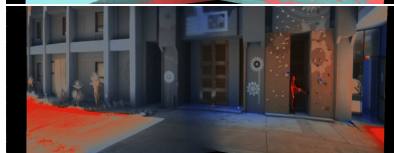


New planar-spherical stitch

All sea-level and distant objects are stitched correctly  
Water edge (B) stitched correctly  
Distant building (D) stitched correctly  
Base of close building (C) which is at sea-level is stitched correctly

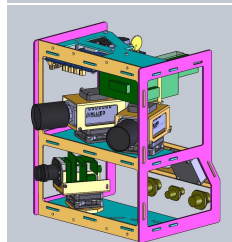
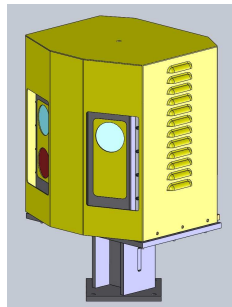


# WASSABBI Fusion Types

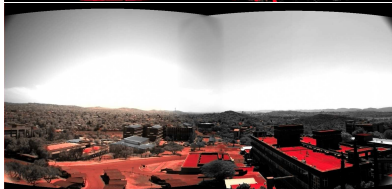
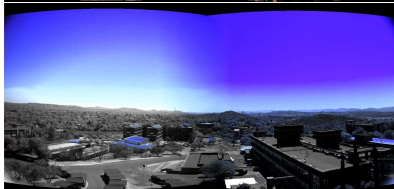
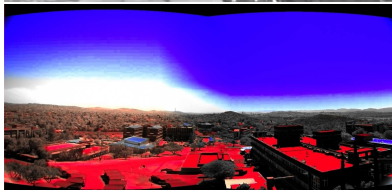
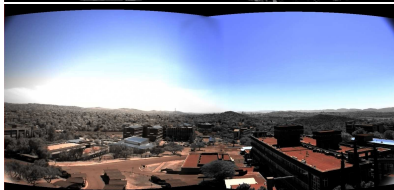
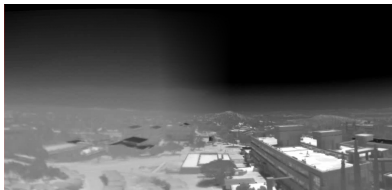


# WASS90+: Bringing it all together

- Evolution of WASS-90 and WASSABBI
- Maritime hardened from start
- No COTS electronics
- Real time Image fusion adjustment
- Improved close range stitching
- Remote power cycling of cameras
- Ease of installation
- Improved user interface
- Improved Integration with CISS



# WASS90+ Tunable Fusion





# WASSAP: CISS for Armoured Platforms

## What is WASSAP?

- 180° fused system on a Ratel
- 5 Colour 1.3 MP cameras
- 3 LWIR Cameras
- Improved driver situational awareness
- Improved targeting for commander
- Upgradeable to 360° system
- Modular & removable

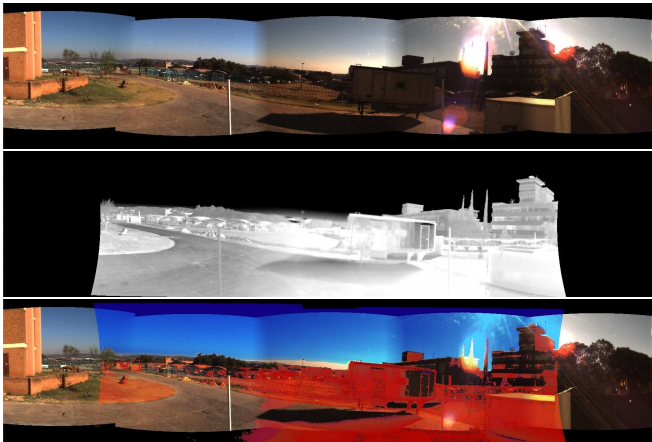


# WASSAP: CISS for Armoured Platforms

## Features and Benefits

- Independant views for driver and commander
- Fixed view for driver to minimise disorientation
- Pan and Zoom in commander view
- Cycle between raw and fused modes in commander view
- Command center integration through DPSS' command and control portal: CMore.
- Colour cameras and Colour fusion.

# WASSAP Screen Shots





# State of Affairs

## Currently Have

- Modular visual WASS system
- Robust tracking of manually selected targets
- Second order ruggedisation
- Ability to calibrate cameras of different FOV & spectra

## Achievements

- 14 Papers on calibration, stitching, stabilisation and ranging
- 6 Field trials / deployments
- 4 Popular media articles covering WASS, 1 TV show
- $\geq 3$  technology packages/demonstrators
- 1 International patent

# State of Affairs: Current developments

## Augmented Reality

- Head mounted display
- Head tracker
- Cut out portion of panorama corresponding to Head angle
- Different view per eye
- Display on HMD
- Training simulators
- One camera array, multiple viewers
- Virtual periscope
- See through armour



# State of Affairs: Current developments

## Embedded Stitching

- FPGA stitching
- “SWaP” optimised
- Can use smaller cameras and no frame grabbers



## New uses

- Harbour patrol and other small vessels
- Aircraft and UAVs
- RHIBs
- Paramilitary



# State of Affairs: Current developments

## Current Developments

- Test and deploy WASS90+
- Helmet mounted displays for WASS: See through armour
- Improve real-time image fusion
- Automatic target detection
- Improve tracking algorithms
- Mini-WASS systems



# The problems we want to solve

## Riverine & Ground Scenarios

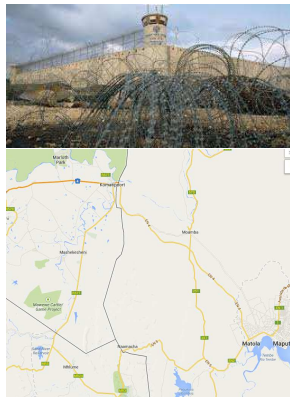
- WASS on a moving vehicle/vessels
- WASS versions for large & small platforms
- Busy thoroughfares
- Threats on one or both sides
- 24 Hour capability
- Targets amongst static obscuring background objects



# The problems we want to solve

## Base & Border Protection

- Static deployment
- Detect intruders
- Vast areas to be covered
- Unmanned systems
- 24 Hour capability



Thank you  
for your attention.  
Questions?