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SAND2009-4263

Unlimited Release

Published July 2009

Metrics for Border Management Systems

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SAND2009-4263
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Metrics for Border Management Systems

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Abstract

There are as many unique and disparate manifestations of border systems as there are borders to protect. Border Security is a highly complex system analysis problem with global, regional, national, sector, and border element dimensions for land, water, and air domains. The complexity increases with the multiple, and sometimes conflicting, missions for regulating the flow of people and goods across borders, while securing them for national security. These systems include frontier border surveillance, immigration management and customs functions that must operate in a variety of weather, terrain, operational conditions, cultural constraints, and geopolitical contexts. As part of a Laboratory Directed Research and Development Project 08-684 (Year 1), the team developed a reference framework to decompose this complex system into international/regional, national, and border elements levels covering customs, immigration, and border policing functions. This generalized architecture is relevant to both domestic and international borders. As part of year two of this project (09-1204), the team determined relevant relative measures to better understand border management performance. This paper describes those relative metrics and how they can be used to improve border management systems.

Table of Contents

1. Introduction.....	5
2. Definitions.....	5
3. Border Definition Metrics.....	5
4. Global/Regional Level Metrics.....	7
5. National Level Metrics	8
5.1. Policies.....	8
5.2. Organizational Structure	9
5.3. Resources	9
6. Border Element Metrics	10
6.1. Personnel.....	12
6.2. Physical Components.....	14
6.3..Conveyances and Equipment.....	15
7. Conclusions.....	16

Appendices

Appendix A - International Agreements/Conventions Related to Border Security.....	17
Appendix B - National Level Human Resource Metrics and Measures.....	18
Appendix C - Quality Function Distribution Sample Chart	19

Metrics for Border Management Systems

1. INTRODUCTION

There are as many unique and disparate manifestations of border systems as there are borders to protect. Border Security is a highly complex system analysis problem with global, regional, national, sector, and border element dimensions for land, water, and air domains. The complexity increases with the multiple, and sometimes conflicting, missions for regulating the flow of people and goods across borders, while securing them for national security. These systems include frontier border surveillance, immigration management, and customs functions that must operate in a variety of weather, terrain, operational conditions, cultural constraints, and geopolitical contexts. As part of the Laboratory Directed Research and Development (LDRD) Project 08-684 (Year 1), the team examined the applicability of the existing physical security Design and Evaluation Process Outline (DEPO) and found that the fixed facility model does not fit well for borders. It is now understood that borders are not easily controlled nor secured at the desired level and therefore, the risks, in general, must be managed. The LDRD team developed a universal border management systems reference architecture that facilitates and guides development of border management and is scalable and customizable for the various domains and specific elements. This generalized architecture is relevant to both domestic and international borders. A systems analysis methodology to identify potential border management system enhancements was also developed.

The research for this project has led to a better understanding of the critical role and application of relevant relative metrics to assess performance of these systems. Based on the border management systems architecture, a set of measures that cut across the multiple domains of land, water, and air and cut across the operational levels of global, regional, national, and border element applications were determined. This approach enabled coverage of the entire problem space and to form the basis for relative comparisons between pre- and post-enhancement. This approach also allows the analyst to compare performance among the many unique and disparate manifestations of border systems.

2. DEFINITIONS

Because border management systems are complex systems occurring in a variety of operational environments, the following are defined for use in this report:

Metric – a characterization attribute used as a basis for comparison to provide meaningful information.

Measure – a standard by which to gauge performance of a metric.

Goal – a desired end state.

3. BORDER DEFINITION METRICS

At the highest level, a border is defined as the boundary that is used to identify the sovereign territory of a country. The measure or attribute of concern at this level is the stability of the

border. The metrics of whether the border is defined and how well is it demarcated are used. For purposes of analysis, border stability is evaluated according to the following attributes:

Attribute	Goal
The degree to which the border is fully defined	Fully defined by geo-coordinates or fixed landmarks
The length of border in dispute	No disputed borders
Whether the border definition and any disputes are registered with the United Nations	Registration with the United Nations
The extent to which the border is demarcated	Fully demarcated border

The analyst should then examine how the border is divided into operational sectors. This includes the official ports of entry (POE) at the three domains of land, water, and air (includes known unofficial ports of entry). The environmental conditions specific to the border sector should be described. This establishes a reference foundation for the analyst. The metrics associated with border sectors primarily focus on surveillance coverage and the illicit movement across borders.

One goal for the border management system is to achieve full surveillance coverage of the border or, at least improve coverage. The measure is based on the length of border under surveillance and then based on quality of the surveillance.

It is also important to understand the traffic currently crossing the border and to examine how that traffic changes as improvements are made to border security. The measures that can be used to determine traffic metrics include: Types and volume of traffic crossing borders at POE and crossing frontier borders. In general, the traffic crossing at official POE is considered to be legal traffic and that crossing frontier borders, is illicit traffic. While smuggling attempts typically occur at POE, there is usually significant smuggling through the frontier borders as well. Smuggling metrics are based on the types of smuggling techniques being used; the ability of the system to functionally detect those techniques; the number of smuggling events; quantity of material confiscated; and number of persons arrested or deported. It should be noted that it is impossible to know what has been successfully smuggled if the border system has never detected it. Understanding the techniques and vectors smugglers use at POE and frontier borders allow for border security upgrades to be measured through the changes in smuggling techniques (requiring more effort and sophistication on the part of the smuggler) or by increases in the volume of traffic interdicted. An assessment can be made about the interdiction success of the border management system if the number of arrests or detainments leading to prosecution increases, the percentage of captured illegal immigrant deportations increases, and the number of repeat offenders decreases.

4. GLOBAL/REGIONAL LEVEL METRICS

The three aspects of global and regional border security are: transparency, cooperation, and communications. The metrics used in transparency relate to how well the county publishes its border policies and are based on the following attributes:

Attribute	Goal
The degree to which border policies are publicly available	Full transparency of border policies regarding immigration, customs, and frontier borders
The degree to which border policies are accessible	<ul style="list-style-type: none"> ○ Available in printed and electronic media ○ Available upon request from ministry(ies)
Consistency of policy throughout all borders	Universal policies applicable to each border sector
The degree to which border policies are shared with neighbors and the international community	Internationally available to all who request and shared with neighbors through information exchanges

The metrics for assessing cooperation are based on participation (defined as a signatory or member state and associated report submissions) in the listed international agreements or conventions associated with border security. The goal should be to be an active participant in each of the agreements listed in Appendix A. A country's participation in a nuclear weapon-free zone can also be considered. A good reference site for identifying participation is also listed in Appendix A.

The metrics for communications at the international/regional level are based on the communication linkages between the country and its neighbors. Measures include the existence of communication linkages, the types of communication linkages, the level of communication linkages how often these linkages are used, under what circumstances, and a determination of whether these linkages are working. The goal should be a communication plan or system that includes cross border communications, regional/national communications, and intelligence communications. The following linkages should be considered internally and with each neighboring state:

- Cross border counterparts
- Site and regional headquarters
- Regional headquarters
- Regional counterparts
- Regional to national headquarters
- National counterparts
- Cross border intelligence counterparts
- Intelligence and border sites

5. NATIONAL LEVEL METRICS

National level metrics are based on the information collected about the border definition, the analysis of border management systems focuses on national level factors such as: border management policies, organizational structure, and resources. The goal of these metrics should be to attain the right balance of organizational structure to ensure policy is promulgated efficiently; chain of command is exercised effectively; and resources are adequate to meet the operational demands of the border elements.

5.1. Policies

Border management policies take the form of doctrine, regulations, and laws. The metrics used in this case are based on the existence of documented doctrine that covers the three functional elements of border management: Customs, Immigration, and Border Policing and whether that doctrine is consistently supported by existing regulations and laws. In the United States, Border Management functions are primarily covered by Title 8 of the Code of Federal Regulations (8 CFR). However, aspects of border management are also covered by Title 19 and Title 9. The key measures are laws and regulations granting border management personnel the authority to perform their jobs, defining jurisdictions, and covering:

- Customs (import and export)
- Immigration (legal versus illegal immigration, citizenship, foreign visit requests, refugees, etc.)
- Search and seizure of persons, conveyances, and cargo
- Legal process requirements

No judgment is made on the quality of the laws and regulations, but whether they exist, are not contradictory, and do not result in any jurisdictional or functional gaps. Therefore, the goals of a unified conduct of operations and a unified code of procedures supported by unified curriculum for training are desired. Conditions under normal operations, abnormal operations (acts of nature such as earthquakes or human error or accidents), and malevolent operations (war, terrorism) should all be covered as well as a clear indication of how border functions carry through to law enforcement and prosecution within the legal system. Some of the legal authorities that border forces should include in a legal system are:

- Legal border definitions and designations of official ports of entry for persons, conveyances, and cargo
- Authorities for decision making
- Jurisdictional limitations
- Security of communications
- Surveillance functions and covertness
- Search and seizure
- Contraband and weapons of mass destruction (WMD) detection
- Examination of documents, persons, cargo, conveyances
- Human rights

- Emergency response
- Use of deadly force
- Visa regime or other travel document requirements for the movement of citizens and foreign nations
- Foreign trade and customs conventions
- Trade agreements or trade sanctions
- Illicit transnational crime or smuggling definitions
- Use of quarantine
- Plant and animal protection
- Hazardous material transport
- Air traffic
- Organization and jurisdiction of government authorities
- Regulation of foreign conveyances

5.2. Organizational Structure

For organizational structure, the metrics are based on the complexity of the management structure and the extent of interagency cooperation. The key measure for this is, determining the level for which a single authority is responsible for border management. The goal for this metric is to have a centralized authority that addresses border management functions in a cohesive and comprehensive fashion. This entity may be a single organization such as the Department for Homeland Security in the United States or may be a council of ministries that are involved with various aspects of border management such as Foreign Affairs, Trade and Tourism, Intelligence and Security, etc. The structure of the chain of command is another metric that can be used with the goal of pushing decision-making to the lowest level to facilitate response to events. Another key measure is having a process for promulgation of change to policies or procedures throughout affected organizations. Communication processes can be improved using standard process improvement methodologies that seek to simplify processes and remove obstacles.

5.3. Resources

Financial, technical, and human resources should be analyzed at a national level. The metrics for financial resources are based on the ability of a country to adequately fund border management and where border management fits within budget priorities. Often, the funding for border management is directly impacted by its position within the organizations responsible for the various functions and the priorities within that agency. If border elements lack basic resources for personnel to complete their jobs or there is insufficient funding to pay for border forces, the effectiveness of the border management system may be compromised. Measures for assessing financial resources can be the:

- Portion of national budget allocated to border management,
- Division in funding between labor, training, equipment, and supplies

- Adequacy of funding to cover border functions.

Metrics for technical resources are based on how well equipment and technologies are supported. The measures for this include the existence of a nationally-based system for logistics supply and training on technologies and equipment and its ability to adequately support border element operations. Another measure that can be used is the Corruption Perception Index¹ published by Transparency International or the prevalence of bribes in border operations.

At a national level, the metrics for human resources are based on costs, whether there is sufficient manpower to cover 24/7 operations at the border for full border coverage, and to manage attrition. Cost measures include the cost of overtime, percentage deviation from allocated budget (overspent or underspent), and training costs. The number of qualified applicants that meet minimum skills, abilities, and knowledge requirements can provide a measure for the available resource pool capacities and the turnover rates can be an indicator for the experience base of the personnel pool. Hours of overtime can be a measure of human resource deficiencies. Additional human resource measures include the existence of a:

- Promotions system
- Rewards and recognition system
- Disciplinary action system
- Resource management system
- Personnel security/assurance system
- Credentials/access control system
- Career development system
- Process improvement system

If this is a targeted area for improvement, Appendix B lists goals and measures that can be associated with these types of subsystems.

A training program plays a huge role in human resource programs. Measures for training programs are based on whether training programs exist, how often personnel are trained and to what level, and the existence of certification programs. Training is also assessed at the border element level to address training needs specific to each border element instantiation.

6. BORDER ELEMENT METRICS

At the border element level, border management systems deal with ports of entry and frontier border operations. There are personnel components, physical components, and information components. There are many opportunities for improvement that are found through characterization exercises described in the analysis framework report.² Since it is the mission of the border element to facilitate legal traffic while interdicting illegal traffic, the first set of metrics relate to the ability of official ports of entry to manage the volume and types of traffic

¹ http://www.transparency.org/policy_research/surveys_indices/cpi

² Duggan, Ruth A., "International Border Management Systems: A Reference Architecture and Analysis Framework, Sandia National Laboratories, SAND2008-6568

typically seen at that site, as shown in Table 1. Functional metrics are based on the ability of a port of entry or frontier border site to accomplish the functions shown in Figure 1.

Table 1. Routine Traffic Port of Entry Metrics

Metric	Measure	Goal
Routine Traffic	Based on daily averages, but also captured per shift and by hour: <ul style="list-style-type: none"> • Number of persons passing through the site versus maximum possible • Number of conveyances passing through the site versus maximum possible • Number of cargo containers passing through the site versus maximum possible 	Maximum number to facilitate commerce and immigration
Traffic Flow	Number of processing steps Processing time per person, conveyance, and cargo container Presence of a separate area for secondary inspection Percentage of traffic (persons, conveyances, cargo containers) stopped or diverted for secondary inspections Processing time for secondary inspections per person, conveyance, cargo container	Lowest number possible Lowest time possible Secondary inspection site away from normal flow of traffic Fewest number of false secondary inspections Lowest secondary inspection time
Function Traffic	Based on daily averages, but also captured per shift and by hour: <ul style="list-style-type: none"> • Immigration processing time • Customs processing time 	Lowest possible processing times for legitimate traffic
Time Lost	Processing time increases due to <ul style="list-style-type: none"> • Inadequate manpower • Uncalibrated or failed equipment • Power or communications systems loss 	Minimal impact to processing times

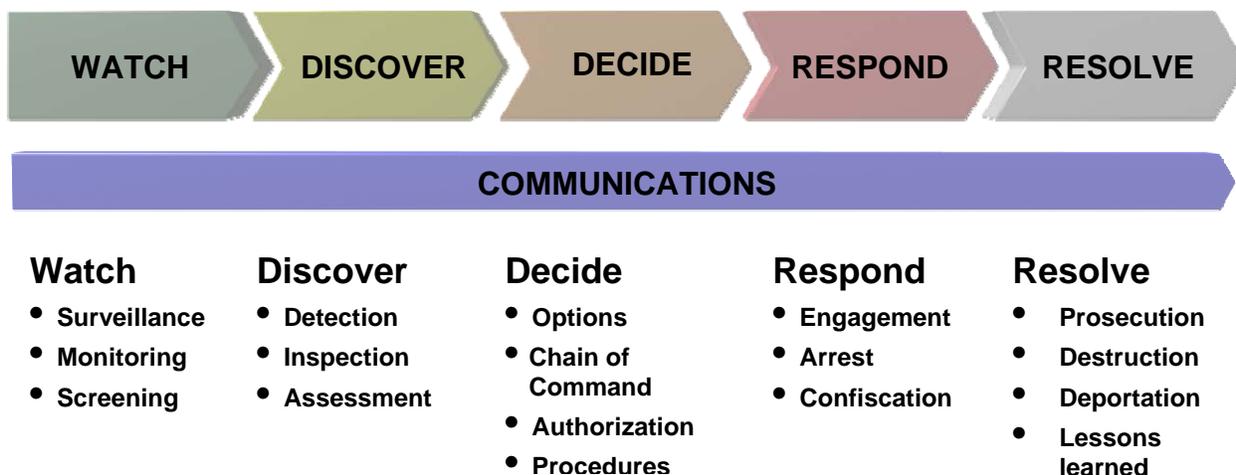


Figure 1. Operational Functions

The existence measures can be characterized using a quality function distribution (QFD) chart such as the one illustrated in Appendix A for a frontier border. The QFD for frontier borders is based on the requirements for detection of illegal frontier borders across the three domains using various transportation modes:

Ground - aerial, vehicular, footpath (human or animal)

Rivers - underwater, ferry, motorboat, canoe/kayak

Coastal - ship, motorboat, canoe/kayak, underwater

Note: the equipment listed in a QFD for detection and inspection should be specific to the illicit traffic of concern at the port of entry and through frontier borders. There are also other, more specific metrics that can be used to determine whether changes to the personnel, physical, and/or information systems have a positive or negative impact.

6.1. Personnel

While the metrics applied at the national level for human resources can also apply at the border element level, the metrics listed in Table 2 should be examined at the local or border element level. Metrics such as turnover rate, absences, access control and credentials, disciplinary action and training should all be examined for each port of entry or frontier border site to assess the impacts of changes to the site level border management system.

Table 2. Border Element Personnel Management Metrics

Attribute	Measure	Goal
Turnover rate	<ul style="list-style-type: none"> • Number of personnel losses versus personnel gains • Gap between personnel needs and personnel available • Number of days to fill a posting 	As low as possible
Absences (vacation, sick leave, etc.)	<ul style="list-style-type: none"> • Number of days lost due to vacation • Number of days lost due to illness • Number of days lost due to injury • Number of hours of overtime due to absences 	As low as possible
Disciplinary Actions	Number of disciplinary actions Number of terminations for disciplinary reasons	As low as possible
Credentials	<ul style="list-style-type: none"> • Existence of distinguishing credentials • Percentage of personnel having credentials 	All personnel have them
Access Control	<ul style="list-style-type: none"> • Number of restricted areas • Number of personnel permitted in each restricted area • Number of credentials that are lost or stolen • Number of persons on access control lists who are no longer at the site or no longer have a need to access a restricted area 	Implementation that limits unauthorized personnel from restricted security areas Limited to fewest number with minimum access attempts Credentials all accounted for and in good shape Updated Access Control lists
Training	<ul style="list-style-type: none"> • Number of personnel with basic knowledge, skills, and abilities • Number of personnel trained on site specific procedures and equipment • Process for capturing lessons learned • Number of lessons learned captured 	All personnel have basic law enforcement knowledge, skills, abilities, and authorities Site specific training is conducted Process incorporating operational lessons learned

6.2. Physical Components

There are many facets to the physical components found in border elements. While there are components unique to ports of entry or frontier borders, there are many components that exist in both contexts. The metrics that are relevant depend on what is present at the site. The metrics listed in Table 3 apply to either ports of entry or frontier border sites.

Table 3. Generic Physical Component Metrics at the Border Element Level

Attribute	Goal	Measure
Infrastructure		
Power	100 % available and conditioned	<ul style="list-style-type: none"> • Number of power outages per year • Number of brown-outs per year • Average duration of each
Communications	100% available	<ul style="list-style-type: none"> • Number of communication system breakdowns • Number of events during which communications failed
Data transmission lines	100% available	Number of times data failed to transmit or be received
Barriers	Well maintained and increase delay to adversary to facilitate detection and response	Delay time provided versus response time after detection
Surveillance	Full coverage of the border for the full range of border threats	Field of view and resolution to observe the entirety of the border
Inspection/Detection	Force multiplying technology/equipment with low false alarm/nuisance alarm rates	<ul style="list-style-type: none"> • False alarm and nuisance alarm rates • Manpower addition or reductions due to addition of technology • Capability added or lost
Response	Timely and sized right for successful interdiction	<ul style="list-style-type: none"> • Response time • Number of response forces versus persons captured

6.3. Conveyances and Equipment

Conveyances and equipment employed at ports of entry or used to support frontier border operations vary from site to site and country to country. This set of measures can be used to determine the metrics for operational level, performance, and logistics:

- Level of operation based on whether the conveyance or equipment is used; if used, for what percentage of operational day or circumstances; and number of personnel able to use the conveyance or equipment.
- Performance based on whether the equipment or conveyance performs its intended function, operates as a force multiplier, personnel error rates, and periodic testing. Measures include the number of unresolved alarms, false alarm rate, nuisance alarm rates, and human error rates.

Logistics are based on:

- Consumable requirements – adequate supplies of consumables (batteries, fuel, ammunition, etc) to meet operational and readiness certification levels
- Spares requirements – appropriate spares available onsite and/or the lead time to get spares
- Repair requirements – mean time between failures, mean time to repair, mean time waiting for repairs, mean cost to repair, period for preventative maintenance
- Training requirements – number of personnel trained to perform basic repairs and specialized maintenance
- Life cycle requirements – costs to implement, duration of utility, and retirement costs

Additional metrics apply to detection systems. These include:

- Range of detection
- Detection field
- Power and communication loads
- Signal-to-noise ratio
- Sensitivity
- False alarm/nuisance alarm rates
- Indicators of state of health
- Calibration frequency
- Interoperability or interface factors
- Environmental factors such as terrain, climate, weather, flora, and fauna

For specific border element instantiations, other metrics may apply. For whatever metrics are used, it is important that measures and goals be associated with those metrics. The measures for assessing this can be based on the following:

- Down-times of border element personnel, equipment, vehicles, weapons etc. due to inadequate battery supplies, lack of ammunition or other consumables such as adequate clothing for environment conditions, oil, and fuel.
- Number of personnel trained on site specific procedures, competency training on basic equipment operation and maintenance.
- Down-time of equipment due to lack of spare parts or maintenance personnel.

7. CONCLUSIONS

Measures of effectiveness may allow for some basis of comparison for old and new methods or procedures as well as technological enhancements to determine the success or failure of changes to a border management system. Using these relative metrics versus absolute metrics allows the analyst to narrow the measurable data collected to answer specific performance questions. Sector ratings can then be used for national strategic planning of resources. To the extent countries are willing to share, the measures can be used to demonstrate the effectiveness of best practices, designs, and equipment/technology while taking into account the unique context in which every system operates.

Collecting data that measures effectiveness requires a dedicated effort to collect and maintain records. In many areas of the world, border management resources are already severely strained. However, for some of these metrics, information may have already been collected and will just need to be analyzed. Lack of these types of measures can limit the ability of a border management system to justify its costs and support its strategic planning, and make it difficult to defend its human, equipment, and technical resource demands.

Appendix A - International Agreements/Conventions Related to Border Security

Border Security

- United Nations Security Council Resolution 1540/1810

Export Control

- Australia Group
- Guidance on the Import and Export of Radioactive Sources
- International Code of Conduct Against Ballistic Missiles
- Missile Technology Control Regime
- Nuclear Suppliers Group
- Wassenaar Arrangement
- Zangger Committee

WMD Nonproliferation

Nuclear/Radiological

- Treaty on the Nonproliferation of Nuclear Weapons (NPT)
- Comprehensive Test Ban Treaty
- Convention on the Physical Protection of Nuclear Material
- Convention on Nuclear Safety
- Joint Convention of the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
- Code of Conduct on the Safety and Security of Radioactive Sources

Chemical/Biological

- Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction (CWC)
- Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons (BTWC)

Reference to measure participation:

http://www.nti.org/e_research/official_docs/inventory/index.html#treaties.

Appendix B - National Level Human Resource Metrics and Measures

Attribute	Goal	Measures
Promotion System	Promotion system based on merit and experience versus age or politics	Percentage of personnel promoted each year
Rewards and Recognition System	Rewards and recognition system that is timely, fair, and provides incentive for improved performance	<ul style="list-style-type: none"> • Percentage of personnel receiving recognition and receiving rewards • Time between performance and recognition or reward
Disciplinary Action System	A system that clearly states conditions for being placed under disciplinary action, who has the authority to do this, and what the results are for success or failure	Percentage of employees under disciplinary action
Resource Management System	A system that covers recruitment, rotations, absences, terminations, retirements, complaints, training, and performance measures	<ul style="list-style-type: none"> • Percentage of employees who leave per year • Percentage of employees who leave within three years of being hired • Average number of days to fill postings • Number of sick days due to illness and/or injury • Percentage of unplanned overtime • Percentage absenteeism
Personnel Security/Assurance System	A system that includes some form of background check with periodic updates and health testing	Number of security violations Percentage of employees with security violations
Credentials and Access Control System	A credential that distinguishes authorized border forces and is used as part of an access control system to limit access to areas to specific personnel	<ul style="list-style-type: none"> • Percentage of personnel with credentials • Number of persons with access per restricted area
Career Development System	A system that promotes the growth and development of its employees	<ul style="list-style-type: none"> • Hours of career development training per person per year • Number of exercises, training courses per employee per year
Process Improvement System	A system for incorporating lessons learned at the national level	Percent of processes and procedures updated annually

Appendix C - Quality Function Distribution Sample Chart For Border Management at Frontier Borders

The horizontal axis lists system design elements for the QFD. A typical frontier border might consist of the following design elements:

- | | |
|--|--|
| <ul style="list-style-type: none"> ▪ People <ul style="list-style-type: none"> ○ Border patrol personnel ○ Customs ○ Coast Guard ○ National or provincial police, ○ Local police
 ▪ Information <ul style="list-style-type: none"> ○ Satellite imagery ○ Video ○ Direct observation ○ Human intelligence <ul style="list-style-type: none"> • Ship cargo manifest • Ship travel plans • Flight plans | <ul style="list-style-type: none"> ▪ Equipment <ul style="list-style-type: none"> ○ Acoustic/Seismic ground sensors ○ Visual ground sensors ○ Heat sensors ○ Radiation sensors ○ Pressure sensors ○ Electromagnetic sensors ○ Magnetic sensors ○ Radar ○ Chemical sensors ○ Buried sensors ○ Underwater sensors ○ Airborne visual sensors ○ Fence/Burm ○ Land vehicle ○ Motorboat ○ Horse or other beast of burden ○ Cellular phone ○ Satellite phone ○ Radio ○ Wi-Fi ○ Fiber optic cable ○ Lind line telephone |
|--|--|

An evaluation system is based on the following set of symbols:

Symbol	Meaning
⊙	Present and directly addresses crossing mode
○	Present, but indirectly addresses crossing mode
△	Weak correlation between crossing mode and design element
	No correlation

Figure A-1 shows how this might look in a QFD chart with some assessment data. Note that this QFD chart also includes assessment of the difficulty the border management system may have in supporting a particular design element. Additionally, weighting of the design elements can be based on the amount of cross-border traffic types.

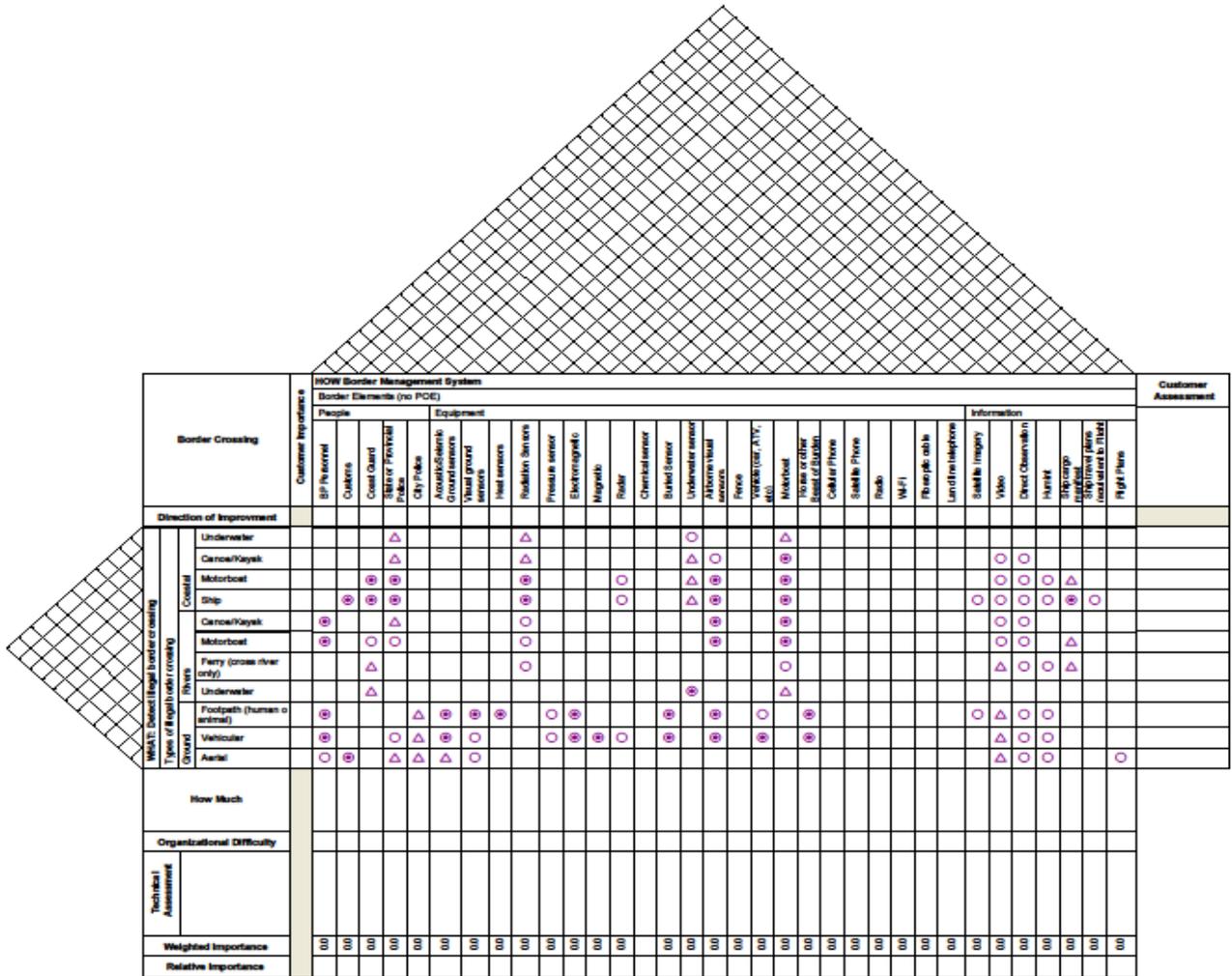


Figure A-1. QFD Chart

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