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A Risk-Based Comprehensive Framework for the Assessment of the Security of Multi-Modal Transport Systems

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Abstract : The challenges of the rapid growth in the demand for transport has traditionally been seen within the context of the problems of congestion, air quality, climate change, safety, and affordability. However, there are increasing threats including those related to crime such as cyber-attacks that threaten the security of the transport of people and goods. To the best of the authors' knowledge, this paper presents for the first time, a comprehensive framework for the assessment of the current and future security issues of multi-modal transport systems. The approach or method proposed is based on a structured framework starting with a detailed specification of the transport asset map (transport system architecture), followed by the identification of vulnerabilities. The asset map and vulnerabilities are used to identify the various approaches for exploitation of the vulnerabilities, leading to the creation of a set of threat scenarios. The threat scenarios are then transformed into risks and their categories, and include insights for their mitigation. The consideration of the mitigation space is holistic and includes the formulation of appropriate policies and tactics and/or technical interventions. The quality of the framework is ensured through a structured and logical process that identifies the stakeholders, reviews the relevant documents including policies and identifies gaps, incorporates targeted surveys to augment the reviews, and uses subject matter experts for validation. The approach to categorising security risks is an extension of the current methods that are typically employed. Specifically, the partitioning of risks into either physical or cyber categories is too limited for developing mitigation policies and tactics/interventions for transport systems where an interplay between physical and cyber processes is very often the norm. This interplay is rapidly taking on increasing significance for security as the emergence of cyber-physical technologies, are shaping the future of all transport modes. Examples include: Connected Autonomous Vehicles (CAVs) in road transport; the European Rail Traffic Management System (ERTMS) in rail transport; Automatic Identification System (AIS) in maritime transport; advanced Communications, Navigation and Surveillance (CNS) technologies in air transport; and the Internet of Things (IoT). The framework adopts a risk categorisation scheme that considers risks as falling within the following threat→impact relationships: Physical→Physical, Cyber→Cyber, Cyber→Physical, and Physical→Cyber). Thus the framework enables a more complete risk picture to be developed for today's transport systems and, more importantly, is readily extendable to account for emerging trends in the sector that will define future transport systems. The framework facilitates the audit and retro-fitting of mitigations in current transport operations and the analysis of security management options for the next generation of Transport enabling strategic aspirations such as systems with security-by-design and co-design of safety and security to be achieved. An initial application of the framework to transport systems has shown that intra-modal consideration of security measures is sub-optimal and that a holistic and multi-modal approach that also addresses the intersections/transition points of such networks is required as their vulnerability is high. This is in-line with traveler-centric transport service provision, widely accepted as the future of mobility services. In summary, a risk-based framework is proposed for use by the stakeholders to comprehensively and holistically assess the security of transport systems. It requires a detailed understanding of the transport architecture to enable a detailed vulnerabilities analysis to be undertaken, creates threat scenarios and transforms them into risks which form the basis for the formulation of interventions.

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